THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 34 JUNE 1912 NUMBER 6

THE SPRING MEETING

The Spring Meeting in Cleveland, now in progress, promises to be one of the most interesting ever held by the Society, and both the Committee on Meetings and the local members in that city have made every provision for the pleasure and profit of the visitors. In addition to the excellent technical program which is offered, full advantage will be taken of the many attractions which the City of Cleveland has to offer. Its location upon the lake makes it a pleasant place to visit at this time of year and its industrial development gives the promise of technical excursions of unusual merit.

The meeting will open under favorable auspices, with an informal reception at the home of Mr. and Mrs. Ambrose Swasey. Especial provision will be made throughout the meeting for the pleasure and convenience of the visiting ladies, and both members and guests will be entertained at the Country Club on Wednesday afternoon. A reception and dance will be the social feature of Thursday evening, and luncheon will be served in the Chamber of Commerce on both Wednesday and Friday. Dr. Miller's lecture on Wednesday evening, on Sound Waves, will have many valuable and interesting features.

The arrangements for the reception of the visitors are in the hands of an Executive Committee of which Past-President Ambrose Swasey is Chairman.

INTERNATIONAL CONGRESS OF NAVIGATION

One of the most notable gatherings of engineers ever held in the United States is now in progress in Philadelphia, where the Twelfth International Congress of Navigation opened on May 23. Official representatives have been sent by thirty governments, chosen for their knowledge upon questions connected with the planning, construction and operation of works for the improvement of inland and maritime navigation. The Congress meets in the United States for the first time, upon invitation of the Government, with which the State of Pennsylvania has joined in making provision for the entertainment of the delegates. The Society is represented by Wm. T. Donnelly, of New York, Honorary Vice-President.

At the opening session on Thursday, President Taft, Governor Tener, Mayor Blankenburg of Philadelphia, Brigadier General Wm. H. Bixby, Mem. Am. Soc. M. E., Chief of Engineers, U. S. Army, and Prof. V. E. deTiminoff, acting president of the Association of Navigation Congresses, addressed the Congress. The work of the Congress proper began in the afternoon of the same day, when many questions bearing upon almost every phase of navigation engineering were taken up, among them the safeguarding of navigation and the prevention of marine disasters.

Trips of inspection and social events will occupy the time of the delegates until May 29, including trips to Trenton, to the South Bethlehem steel works and anthracite coal region, to Atlantic City and to Cape May. Arrangements have also been made for a party of the delegates to leave Philadelphia on June 3 for a tour of the Great Lakes, and members of the Society in attendance at the Spring Meeting have been especially invited to join this excursion upon its arrival in Cleveland on June 10, continuing to Detroit, Sault Ste. Marie, Milwaukee, and Gary, Ind. Those who may desire to participate are requested to communicate at once with Lieut. Col. J. C. Sanford, General Secretary, Twelfth International Congress of Navigation, Room 344, The Bourse, Philadelphia, Pa.

It is expected that many of the delegates will visit New York after the Congress has adjourned and a committee, consisting of

Charles Whiting Baker, Chairman, W. M. McFarland, H. deB. Parsons, George B. Massey, Stevenson Taylor, John W. Lieb, Jr., and Jesse M. Smith, has been appointed and has already extended to the delegates a cordial invitation to make use of the Society rooms during their stay. The City of New York has offered the use of one of the Municipal Ferries on Tuesday, May 28, for a tour of the city's waterways, going from the battery down the Narrows, up the East River to Hell Gate, and up the Hudson as far as Yonkers, thus affording a view of the docks, ferries, and other inland traffic arrangements. Luncheon will be served on board.

On account of the conflicting dates of the Spring Meeting of the Society, more formal entertainment of the delegates has unfortunately been impossible at this time. Their welfare, however, will be well cared for by the American Society of Civil Engineers who have planned a series of receptions and excursions. On June 6, an excursion to Albany on one of the Day Line steamers has been arranged and members of the Society are invited to participate. This trip will include stops at Interstate Palisade Park, where the "Half-Moon" will be on view, at West Point, either at Newburgh or Poughkeepsie where the "Clermont" may be seen, and will proceed from there direct to Albany. Those who desire may return the same evening by train. The cost will be the regular Day Line rates, $1 to West Point and return, and $2 to Albany one way.

LOCAL MEETINGS OF THE SOCIETY

No further meetings of the Society in Boston , New York, Philadelphia and St. Louis will be held until next September. The members living in Boston and its vicinity will coöperate, however, in a meeting of the American Institute of Electrical Engineers on Saturday, May 25, when the topic of Low-Pressure Turbines will be considered. In St. Louis the members will join with the Associated Engineering Societies of that city in a meeting under the auspices of the Engineers Club, on June 5, when Mr. A. Lee Moorshead, Associate Member of the American Society of Civil Engineers, structural engineer of the Erie Railroad, will give an illustrated lecture of the construction of the Bergen Hill Four-Track Tunnel Line at Jersey City, with which Mr. Moorshead has been personally connected.

HONORARY MEMBERSHIP CONFERRED ON DR. DIESEL

At a meeting of the Society held at the headquarters on the evening of April 30, Honorary Membership was conferred upon Dr. Rudolph Diesel of Bavaria. Dr. Humphreys, President of the Society, presided and called upon Col. E. D. Meier, Past-President and chairman of the committee of arrangements, to present Dr. Diesel for honorary membership.

Colonel Meier spoke of the debt of early civilization to the discovery of fire, which became an object of worship even among the most cultured peoples of the ancient world and said that the mechanical energy of heat through the medium of steam had been utilized more than two thousand years ago to open and close the massive doors of the Egyptian temples. Less than two centuries ago James Watt first applied the same power to the useful arts, and manufactures, means of transportation, mining, metallurgy, and the production of all things useful and beautiful increased a thousandfold. At first scarcely two per cent of the power locked in the fuel could be utilized. The genius of Woolf, Corliss and their followers increased this to six, eight, and finally nearly fourteen per cent. Beau de Rochas, Otto, Priestman, and other engineers, abandoning the intermediary steam, produced explosive engines in which the direct conversion of heat into power reached a useful effect of twenty per cent.

In 1897 after a persistent, patient, scientific effort of fifteen years, Rudolph Diesel presented to the engineering profession an internal-combustion engine in which controlled combustion replaced explosions, from which ignition troubles were banished and which reached twenty-eight per cent of efficiency, since gradually increased by further refinements in design to thirty-five per cent.

Based on careful search and investigations in independent lines, Lord Kelvin and the Imperial German Patent Court declared Diesel's process to be absolutely new. After ten years of successful practical demonstration in as many different countries and with a greater variety of fuels had proved his engine a great conserver of

the precious fire, the Royal Technical University of Munich conferred on Rudolph Diesel the dignity of the degree of Honorary Doctor of Engineering and the Technical Sciences, as "the inventor of the heat-motor which bears his name, the successful champion for the improvement of the working process of thermo-power engines, whose invention has advanced technical science and opened new avenues for the utilization of a widely disseminated fuel."

It is for these reasons that the Council of The American Society of Mechanical Engineers confers Honorary Membership on Dr. Diesel.

The certificate of membership was then formally presented to Dr. Diesel, who expressed his hearty thanks for the honor done him, and said that his work would never have grown to its present importance if he had not found in the United States, as in other countries of the world, industrial men and engineers who were not afraid to devote their material means and their scientific and technical knowledge to the development of ideas which they recognized to be right and to which they remained faithful amidst difficulties and prejudice. Dr. Diesel acknowledged gratefully Col. Meier's contribution to the development in America. The Diesel engine is not and can not be the work of one man only, but is the combined work of many. He expressed himself proud of a place among such names as Edison, Carnegie, DeLaval, Westinghouse, Isherwood and others who were Honorary Members of the Society.

An address upon the Development of the Diesel Engine was then made by Dr. Diesel, under the auspices of the Gas Power Section of the Society. This address appears in full in this issue of The Journal.

MEETING OF MASTER STEAM AND HOT WATER FITTERS

The members of the Sodiety have been cordially invited to attend the annual convention of the National Association of Master Steam and Hot Water Fitters, to be held at the St. Charles Hotel, Atlantic City, N. J., June 10-13. The Society recently coöperated with a committee of the association in formulating a schedule of standard weight and of extra heavy flanged fittings, published in the February issue of The Journal, which has been recommended to manufacturers for adoption.

MEETING OF THE COUNCIL

A regular meeting of the Council was held on Tuesday, May 14, President Humphreys presiding, at which the applications for membership recommended by the Committee on Membership were approved.

Desiring the assistance of the membership in the preparation of rules for the conduct of local meetings, the Council has invited each of the cities where meetings are now held, to send two representatives to a conference which will be held in Cleveland during the Spring Meeting, so that the views of all may be represented in the resolutions adopted. In consideration of this conference, action was deferred upon the requests received from St. Louis and San Francisco for the privilege of formulating geographical sections.

The report of W. H. Blauvelt and B. F. Wood, who represented the Society at the recent Conference on Patent Law held in Washington, was received and approved.

The report of the sub-committee on Constitution and By-Laws, giving the phraseology of the proposed amendments to the constitution, was received and approved, and these amendments ordered presented at the business meeting to be held in Cleveland.

The Council approved heartily of the work of the committee on reception to the delegates of the International Congress of Navigation, of which Charles Whiting Baker is chairman.

NEW PROCESSES FOR CHILLING AND HARDENING CAST IRON

By Thos. D. West

ABSTRACT OF PAPER

This paper outlines a series of experiments to determine the effect of different methods of treatment in chilling or hardening cast iron during the process of cooling after pouring the mold.

The first experiments showing how to produce mechanically mottled and white iron inside a gray body led to experiments with chillers used in different ways; and with various other heat-absorbing or hardening media, such as air, charcoal, powdered manganese, cyanide, etc. A study was made of the effectiveness of chillers of different thicknesses and of different metals; of the effect of cooling chillers, etc.

The experiments indicate, among other results, that the accepted idea of chilling occurring entirely while the molten iron is solidifying is wrong; and they show how stronger grades of iron can be used for car wheels, rolls, etc., and still obtain the desired depths of chill in such castings. They also demonstrate the superiority of air cooling over metal chillers.

NEW PROCESSES FOR CHILLING AND HARDENING CAST IRON

By Thos. D. West, Cleveland, Ohio

Member of the Society

Conditions are occasionally such that an "inside chill" is produced in castings, by which is meant that a casting with a gray or soft exterior may have the interior, or portions of it, composed of a hard, white or chilled iron, as shown in Figs. 2, 3, 9 and 10.

2 While inside chilling is claimed to be produced by hydraulic pressure, this is not the inside chill which has puzzled foundrymen, and prior to the mechanical creation of inside chill by the author, no one, as far as he knows, has explained how it could be produced at will. The discovery of how this can be done is due largely to experiments which the author has been conducting during the past two years with a view to overcoming the defects now existing in chilled car wheels, and this investigation led to other lines of research, as will be seen herein.

3 Most of the experiments were made at The West Steel Casting Company, Cleveland, Ohio. This company makes castings by the converter and crucible methods, the former requiring a cupola similar to that used in iron founding, and so permitting the casting of chillable metals. The irons used were approximately of the following composition: Carbon 2.75 to 3.25; silicon 1.75 to 2.00; sulphur around 0.06; manganese and phosphor each about 0.04. In cases where a more chillable metal was desired, small portions of stick or powdered sulphur were dropped on top of the molten metal when in the hand ladle.

4 In Fig. 1 is illustrated the experiment that created mechanically an inside chill. This gives views of the mold used in casting test specimens in open sand of the size seen in Fig. 5. The bar *A* was cast

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against a chiller block as at E, while bars B, C and D were surrounded with rammed sand. The bars having been poured, the gate connections F, G, H and I were broken and the sand around C and D removed as soon as their solidification would permit. When it was thought C and D would stand the pressure of tongs, they were lifted quickly and C was doused into a pail of water, while D was broken by an assistant to display conditions of its interior. The immersed bar C having cooled to a dark color, it was taken from the water and broken, and displayed an inside chill, such as is seen at E',

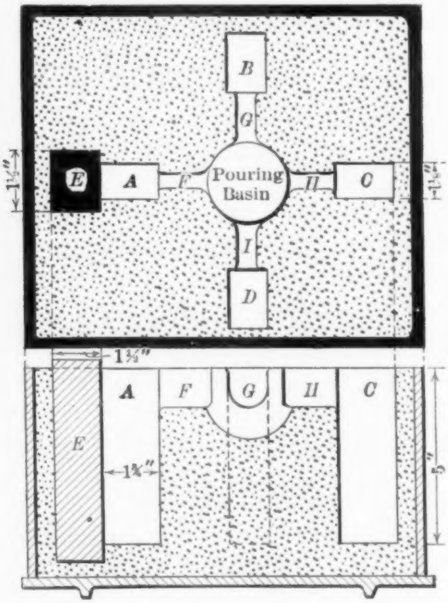

Fig. 1 Mold for Test Bars that Solved Inside Chill Problem

Fig. 9. The bar D showed an interior condition bordering on semi-molten metal. The chilled bar A showed that the chiller E had chilled the surface of A about $\frac{1}{2}$ in. deep, while the bar B had a nice gray fracture. Bars A and B were not removed from their molds until nearly cold.

5 The philosophy of mechanically creating an inside chill exists in the outside body of a casting cooling slowly enough to allow the carbon to take a graphitic form, while the inner body, which is not wholly solidified, is cooled so rapidly that the carbon is held in the combined form, similar to the way it is held in the molten metal.

The graphitic state of the carbon in the solidified body causes the iron to be gray and soft, while the combined state causes it to be hard and white, or chilled.

6 The ability to create an inside chill by strictly physical manipulation led to the belief that it might be practicable to increase the depth of a chill beyond what present chillers can do, with like irons. Especially was this thought practicable for such castings as chilled car wheels and rolls. Several methods were devised for testing purposes, but finally those in Figs. 4, 7, 8, 13 and 14 were adopted for the chief researches. These devices admitted of a wide range for experiments and as a rule led to satisfactory results.

VARIABLE CONDITIONS AFFECTING CHILLING

7 As many who are interested in founding are not cognizant of what is involved in the chilling of cast iron, the following recital is given of actions that take place and of conditions that exist in the process of chilling:

- *a* Iron is chilled prior to any formation of graphite. A chill may be made harder by continuing to cool it while the adjoining metal is still in a semi-molten state or very hot; as by this action any backward annealing to soften the chill is more or less retarded.
- *b* Under like conditions, the lower the silicon and the higher the sulphur and carbon, the deeper the chill.
- *c* Under like conditions, the chill will be deeper the smaller the area of the cross-section to be chilled.
- *d* Under like conditions the less the thickness in the chiller below what can be utilized, the less the chill in the casting.
- *e* The longer the casting remains in close contact with its chiller while its metal is in a chillable state, the deeper the chill.
- *f* The more fluid or the hotter the metal used in pouring a chiller mold, all other conditions being the same, the deeper the chill, from $\frac{1}{8}$ in. to possibly $\frac{4}{8}$ in.; and the greater the chillable nature of the metal, the more pronounced this effect.
- *g* Not all grades of cast iron are chillable. It requires, as a rule, for iron of a general carbon, less than 2 per cent of silicon and above 0.06 per cent of sulphur.

h On account of the variable percentages of silicon, sulphur and carbon required to produce chilled castings, ranging from 1.75 down to 0.50 for silicon, from 0.10 down to 0.05 for sulphur, and from 4.00 down to 2.50 for carbon, it can be seen that there must be what are commonly called "grades" in chillable irons.

MOLD FOR MAKING COMPARATIVE CHILLING TESTS

8 In order to make comparative tests, a twin-chiller mold was

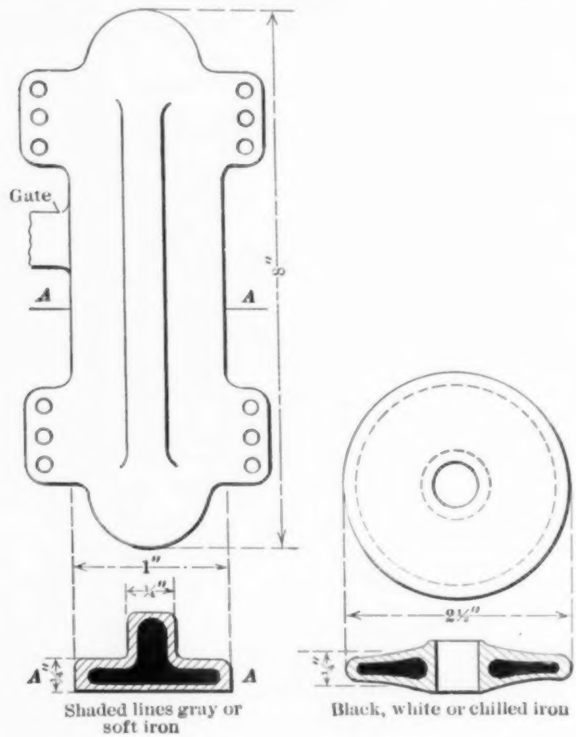

Fig. 2 Fig. 3

Castings with Gray Exterior and Chilled Interior

designed, shown in Figs. 4, 7 and 8. By having the two molds combined so that they could be poured from the same basin, it was possible to make all the conditions alike in both, except the one which it was desired should vary for the particular test under way. The mold was further designed to produce conditions similar to those

existing when casting chilled car wheels and rolls. In making these latter castings the contraction of the chilled crust and the expansion of the chiller create a space between the exterior body of the casting and the interior face of the chiller. The ability to create a space as above in this experimental mold and to apply a heat-absorbing element to it in connection with other actions or treatment referred to later on, made it possible to conduct a large number of very satisfactory comparative tests.

9 In order to obtain a variable action so far as the chillers *P*, Fig. 4, were concerned, the braces *M* were removed and the wedges *N* driven down. If it were desired to have the space *K* in both molds, two persons were employed to work in unison at their respective ends. The wedges *N* would not be knocked down until the metal filling the mold showed evidence at the top edge of the bars of having solidified sufficiently to produce a self-sustaining crust. It was rather remarkable in the air-cooling tests, to be described later on, how clearly the rate of cooling and inner solidification could be judged by the changing color of the hot metal at the top edge of the bars next the chillers.

10 In casting bars intended to be kept in close contact with their chillers, either the runners connecting the pouring basin with the mold must be broken as soon as the metal in them has solidified sufficiently to permit such action; or care must be taken when pouring the molds not to fill them any higher than the level of the bottom of the pouring runners. By these means the disturbing influence due to the contraction of the runners and pouring basin is avoided.

11 Fig. 5 shows the form and size of the pattern used for molding the bars, while Fig. 6 is that of the manipulative chiller *P* employed in these tests. Each of these chillers weighs 3 lb. 14 oz. and the bars made from the pattern, Fig. 5, averaged 3 lb. and 4 oz. As Figs. 7 and 8 show devices for other purposes than those displayed in Fig. 4, comments on them are deferred.

FIRST EXPERIMENTS FOR DISCOVERING VALUE OF HARDENING MATERIALS

12 In starting to use the twin-chiller molds shown in Figs. 4, 7, and 8, the first manipulation was to draw back the chiller *P* of one mold about $\frac{1}{4}$ in. from the face of its bar casting as soon as the latter had solidified sufficiently to have a self-supporting crust facing the chiller, while the companion bar was left in close contact with its chiller until of a dark color (see Fig. 4).

13 In various tests a $\frac{1}{4}$ in. space *K*, Fig. 4, was formed by moving back the chiller, and the effect tried of quickly packing different materials into this space upon the backward movement of the chiller. The materials tried at different times were fine sand, coke dust, charcoal, powdered manganese, bone dust, hardening powder and poisonous cyanide. These tests were made with a view to determining whether such filling of the space would increase the depth of chilling in a bar, or cause it to be any harder than when the chiller remained in close contact with the bar until the latter was nearly cold.

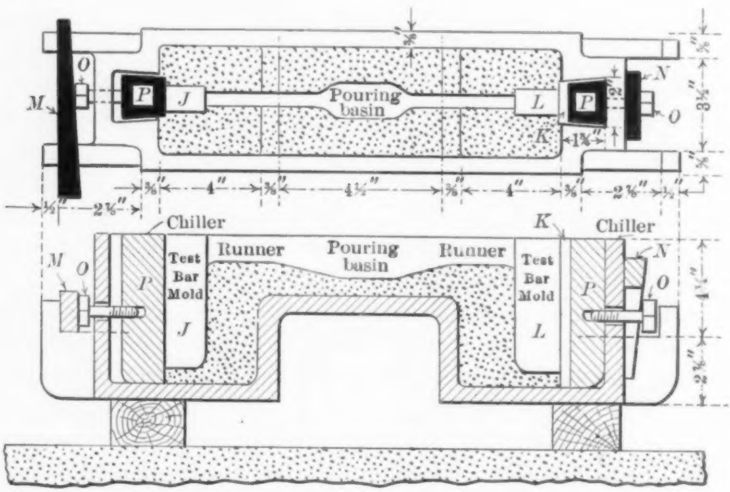

Fig. 4 Mold for Making Chilled Twin Specimens for Fracture Tests

14 No noticeable effects were produced by the use of these intended hardeners. The thickness of chill of the bars kept in close contact with their chillers exceeded that of the treated bars by from $\frac{1}{4}$ to $\frac{3}{8}$ in. This was to be expected, as the withdrawal of the chillers *P* to create a packing space broke the contact of the chillers with their bars at the crucial moment, so far as their effectiveness was concerned in increasing the depth of the chill.

SECOND EXPERIMENT FOR DISCOVERING VALUE OF HARDENING MATERIALS

15 In this series of tests, both chillers were pulled back at the same moment to create spaces adjacent to both bars, as at *K*, Fig. 4. The tests were to discover if any greater depth of chill or hardening

was produced by packing one of the spaces quickly with the materials used in the first experiments while the other space was left open. The series showed the chill to be from $\frac{1}{16}$ in. to $\frac{1}{8}$ in. deeper in several of the treated bars than in the non-treated bars.

16 Tests for hardness, except for the cyanide, showed a gain of 6 to 10 per cent by the scleroscope. One cyanide test with companion all-chilled bars averaged 68 for the treated and 70 for the non-treated; while with another set of companion bars which were not chilled the non-treated bar gave 58 and the treated bar 50 on an average. This softening action of the cyanide may have been due to the fact that the bars were not cooled in water after treatment, as is necessary when case-hardening steel with cyanide. A

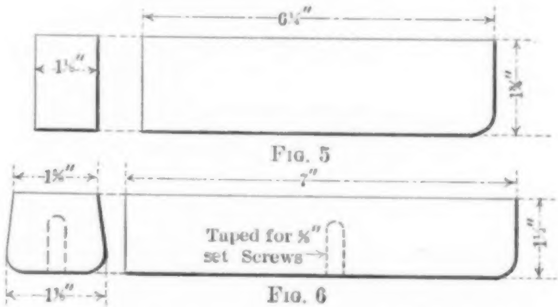

Fig. 5 Fracture Test Bar Pattern; Fig. 6 Manipulative Chiller

peculiar effect of the cyanide is to produce a denser and a finer crystallization of the treated chilled face about $\frac{1}{8}$ in. thick.

IMMERSION EXPERIMENTS

17 For this series, open sand molds of the plan shown in Fig. 1 were used, and by the aid of an assistant, two of the four bars were removed as soon as the crust solidification permitted. One of these bars was immersed and moved around in a pan of mud, which in some tests had salt mixed with it, while the second bar was simultaneously submerged in a pail of water. These tests were duplicated by having the pan nearly filled with a high fire-test oil in place of the mud.

18 Tests made by the second use of the open sand mold, Fig. 1, showed that the mud or oil cooling had little or no effect in chilling, on the average, while the water cooling was radical in its action. *A′*, *B′*, *C′*, and *D′*, Fig. 9, give a fair illustration of these tests. *A′* is the chiller-cooled bar; *D′* the all-sand one; *C′* the mud-cooled bar

and D' the one placed in water. Bars A' and D' were both left in their molds to cool naturally.

19 The bar D' displayed an inside chill as seen by the white appearance at D' and the gray corners and surface indicated by M'. The best sample of this effect, which was closely duplicated in several tests, is seen at E' in connection with the chiller-cooled companion bar F', which latter was cast against the face of the chiller E, Fig. 1, the same as bar A' in Fig. 9. The bar F' showed that a harder grade of iron was used than for A'.

20 The writer's experience in producing this inside chill mechanically, demonstrates it to be a sensitive process partaking of numerous forms, yet all verifying its practicability.

21 It is not improbable that castings, or sections of them, will eventually be produced in a regular manner for commercial use, having a gray or mottled exterior crust, while the adjoining or interior body of metal will be of a mottled, chilled or white iron. The writer can conceive of castings in which this combination of hardness might prove useful, but as his ideas might be considered visionary, he refrains from mentioning them.

TABLE 1 SCLEROSCOPE TESTS FOR HARDNESS *

Set Number of Tests	Set 1	Set 2	Set 3
Average of air-cooled chilled bars	56	65	61
Average of natural-cooled chilled bars	48	58	53
Average of increase in hardness effected	8	7	8

* The writer is under obligations to the kindness of Mr. Walter D. Sayle, president of the Cleveland Punch & Shear Works, Cleveland O., for the scleroscope tests given herein.

HARDENING A CHILLED BODY WHEN HOT BY IMPINGEMENT OF AIR AGAINST ITS SURFACE

22 Special attention was paid in this series of tests to the hardening effect of air applied directly to the hot chilled face of a bar. For tests of this character it is essential that the depth of chill in the comparative bars be of the same thickness. This condition was obtained by admitting the air to the treated bar only after it was thought the inner metal had all solidified, so that it could not be held responsible for any variation of depth of chill in the treated bars. Only three specimens of this series were tested by the scleroscope, as given in Table 1; but from filing and grinding tests made as a check on the results it is evident that a chill's hardness can be very materially increased by applying air, etc., as herein described.

23 Tests of the gray sides of the chilled bars for the second and third sets in Table 1 gave 52 and 42 respectively, showing them to average 25.4 softer than the chilled sides which had received the air treatment.

EFFECT OF AIR SATURATED WITH WATER

24 This series was conducted with a view to learning whether air saturated with water might be more effective than air alone in creating a chill, or in hardening. There was some difficulty at the start in obtaining satisfactory saturation, but this was finally secured by the use of a device which made it possible to vary the proportion of air or water as desired.

25 The series was instructive in demonstrating that so far as the chilling was concerned there was little to be gained by the saturated air, or what was gained would be secured by the use of a greater volume of air alone, so that the water could be dispensed with. This is not, however, to belittle the effectiveness of saturated air as a hardening medium, for among the tests in which saturated air was strongly applied, one gave 70 for the treated bar, and 52 for the non-treated bar, a gain of 34.6 per cent due to hardening.

SOFTENING EFFECT OF ANNEALING CHILLED IRON

26 Specimens of this series of tests were cast in the twin-chiller mold, as arranged in Fig. 8, without applying any air cooling to either chillers. This gave the same depth of chill in both bars. Several sets were cast and annealed, but only one set was tested by the scleroscope. Other sets showed by filing and grinding that they checked closely with those tested by the scleroscope. The annealing was done as follows: The bars were taken out of their mold together and one left in the open air, of about 70 deg. fahr., while the other was laid on the bottom of a hot crucible furnace, the oil fire having been shut off, and left there about twelve hours.

27 The chilled side of the unannealed bar tested at 68 and the gray side at 45. The chilled side of the annealed bar tested at 47 and the gray side 35. This gave a difference for the chilled sides of 21 and for the gray sides of 10.

RELATIVE EFFICIENCY OF WARM AND COLD CHILLERS

28 In order to be assured of correctness in his researches, the author undertook to determine the efficiency of different metals, and of different thicknesses of metal, for chillers and the relative efficiency of warm and cold chillers.

29 To determine the latter two chillers, both alike, were used, one of which was heated to various temperatures, from one bearable to the hand to one that would burn the flesh, while the other chiller was kept at the temperature of the atmosphere. The first three sets of these tests were made on a day when the thermometer registered 62 deg., and the second set of four tests when it was 55 deg.

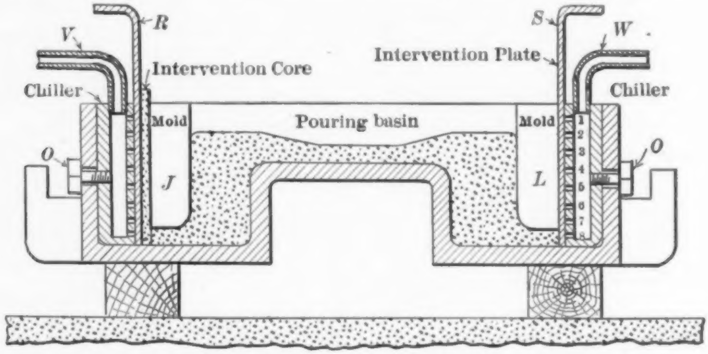

Fig. 7 Intervention Plate System for Air Cooling and Chilling of Molten Metal

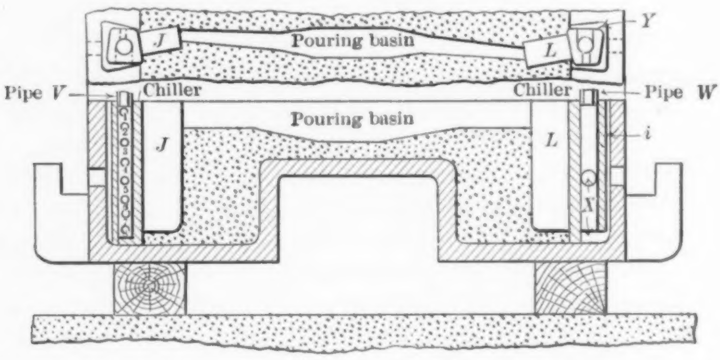

Fig. 8 Chiller Mold for Testing Chilling Effect on Castings by Cooling Chiller

The tests showed from $\frac{1}{16}$ in. to $\frac{3}{16}$ in. greater depth of chill in the bars having the cold chiller than those having the heated ones. Having recently read the claim that a warm chiller would chill deeper than a cold one, it was thought necessary to learn whether such was a fact, as it is unreasonable to expect such a result.

EFFICIENCY OF DIFFERENT THICKNESSES FOR CHILLERS

30 To determine the effect of different thicknesses for chillers,

tests were made by the writer at the Cleveland branch of the National Car Wheel Company, as well as at the foundry of The West Steel Casting Company. For this series open sand molds were used, as seen in Fig. 11. The chillers as shown were respectively $\frac{1}{4}$ in., $\frac{1}{2}$ in., $\frac{3}{4}$ in., 1 in., 2 in. and 3 in. thick; and all 2 in. wide by 9 in. deep.

31 The test specimens cast against these chillers in the wheel foundry were $1\frac{7}{8}$ in. by $2\frac{1}{2}$ in. and 8 in. long, and at the steel foundry, because of having a less chilling metal, they were of the size shown in Fig. 5. The top row of fracture views, Nos. 1 to 6, Fig. 10, is a fair representation of results obtained. The thickness of chill in the samples shown in Fig. 10 is approximately as marked. A study of these samples demonstrates that the efficiency of chillers in general use is far from being in accord with their thickness. The 3-in. chiller, for example, produced but $\frac{3}{16}$ in. more depth of chill than the 1-in. chiller.

32 Aside from their value in other ways, these tests suggest the advisability of makers of chilled rolls, car wheels, etc., trying steel metal chillers in place of the much heavier cast-iron ones. Steel chillers need be made only of the thickness required for efficiency in cooling and would still be strong enough to resist the contraction and expansion strains to which chillers are subjected. There is a liability of difficulty being encountered in using steel chillers on account of the steel warping through repeated heating. By using ribs or giving a special form to steel chillers this objection may be greatly reduced, if not wholly overcome.

EFFICIENCY OF DIFFERENT METALS FOR CHILLERS

33 It was important, at least to the writer, to know whether any difference existed in the efficiency of chillers of gray, white or all-chilled cast iron or of steel or wrought iron. Tests were made with these different metals at both foundries. Two sets of chillers were used, one 2 in. square and the other 1 in. by 2 in., all close to 9 in. long. Aside from grinding one face of these chillers to remove the scale and make them smooth, as with all other chillers used in the experiments of this paper, they were chipped or ground at their lower ends if needed, to make them all of the same weight. The plan of the open sand mold used is shown in Fig. 12. The test bar patterns were of the same size as used for the tests of Fig. 11, about four sets being cast from each size of pattern. While slight differences in the thicknesses of the chills resulting from chillers of the different materials seemed to indicate that one or another of the

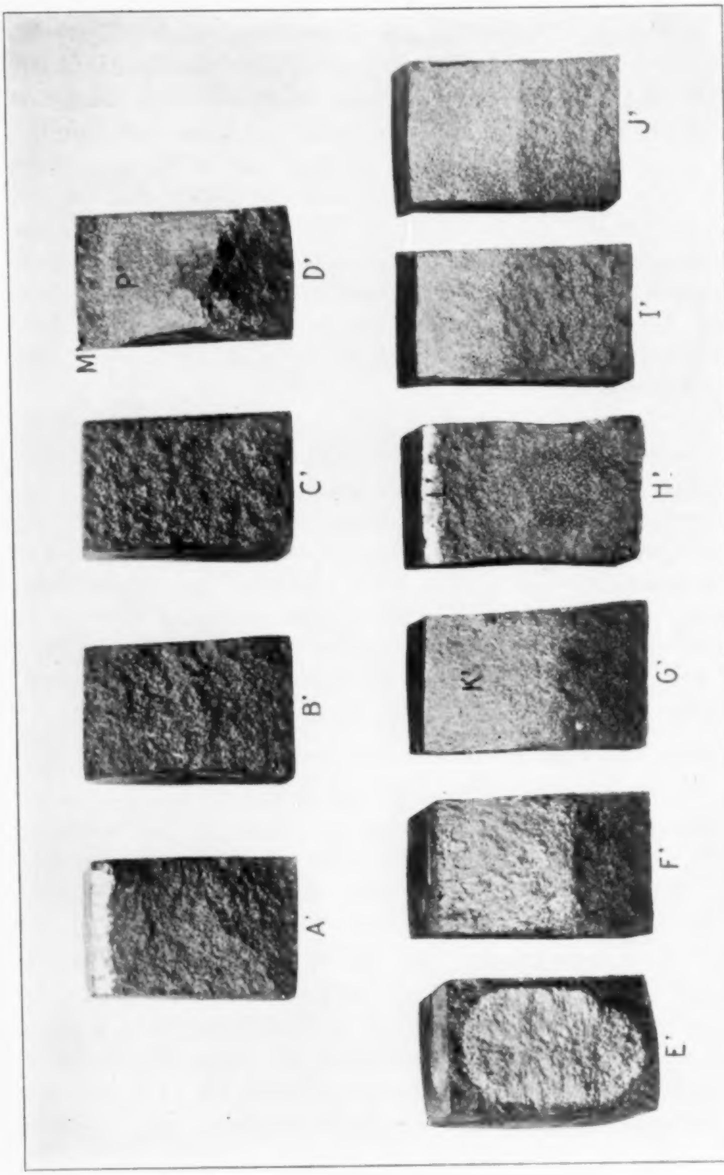

FIG. 9 SAMPLES OF TEST BARS. UPPER ROW SHOWS RESULTS OF IMMERSION EXPERIMENTS. IN THE LOWER ROW *E'* SHOWS AN INSIDE CHILL, *F'* A CHILLER-COOLED BAR AND THE REST ILLUSTRATE THE SUPERIORITY OF AIR CHILLING OVER METAL CHILLERS

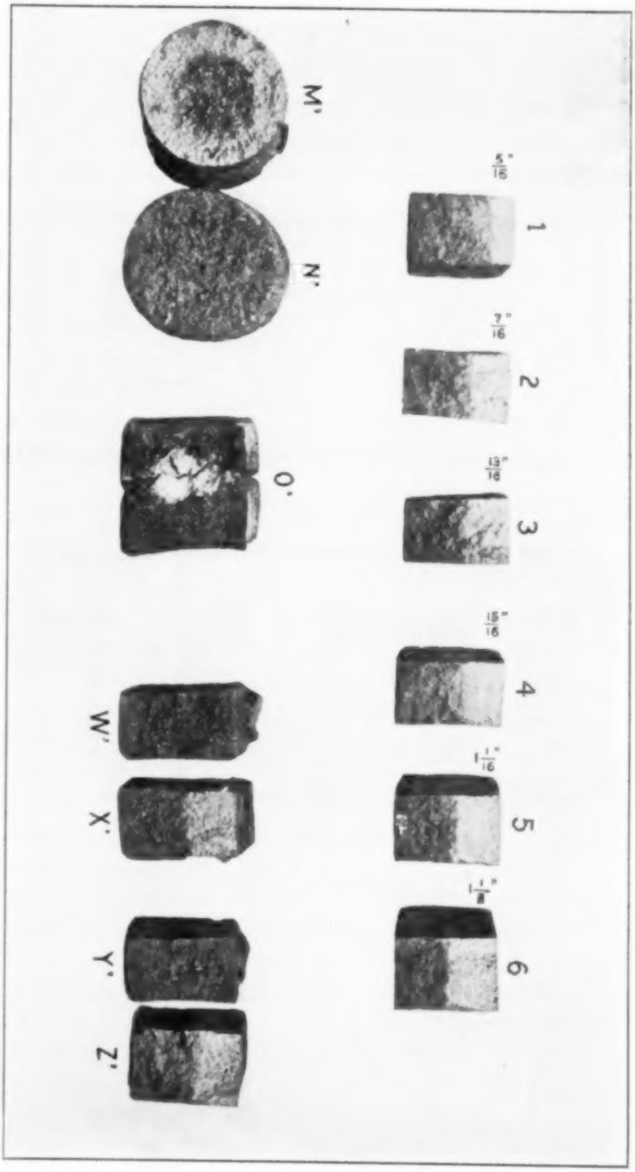

FIG. 10 SAMPLES OF TEST BARS. UPPER ROW ILLUSTRATES EFFICIENCY OF CHILLERS OF DIFFERENT THICKNESSES; LOWER ROW, RESULTS WITH SAND-FACED MOLD AND AIR-COOLED BARS CONTAINING VANADIUM AND TITANIUM

materials produced the deepest chill, there was so little practical difference in the results, taking an average of all the tests, that none of the chillers could be rated as being decidedly better than the others.

VALUE OF COOLING CHILLERS

34 The chief information sought in this series of tests was whether, when a casting contracts away from a chiller, the depth of chill is increased by cooling the chiller, and at what point the cooling

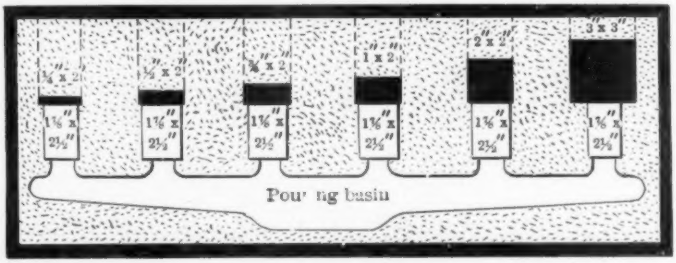

Fig. 11 Testing Efficiency of Different Thicknesses of Chillers

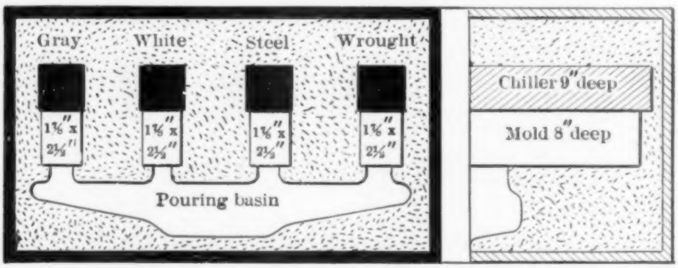

Fig. 12 Testing Efficiency of Different Metals for Chillers

ceases to have this effect. The chillers for these tests were arranged so as to have the orifices 1 to 8, Fig. 7, turned away from the face of the mold as in Fig. 8. This gave a solid surface to the body of the chiller fronting the mold, and prevented the air used to cool the chiller from impinging on the hot face of the bar. For the first tests, intervention plates S were used for fronting each chiller, after the ideas displayed in Fig. 7. As soon as solidification of the metal at the face of these plates would permit, they were pulled out simultaneously to create a space between the bars and their chillers, as seen by the opening at K, Fig. 4. The plates S removed, air of about 50 lb. pressure was admitted to one of the pipes, as at W,

Fig. 7, which passed down the bore of its chiller to find exit at X, and at the orifices 1 to 8 to the exterior of the chiller; from whence it passed upward and escaped to the external atmosphere from around the opening Y in the plan view of Fig. 8.

35 In the use of chillers for car wheels, rolls, etc., the contraction of the casting and expansion of the chiller leave a space between the two, and these tests were therefore well adapted to demonstrate whether internally or externally cooled chillers used for this class of castings would produce a deeper chill than those not cooled. Half a dozen tests were made without finding any practical difference in the depth or character of the chill produced by the air-cooled chiller bars and that of their companions which were not cooled.

36 Following these tests, fully six more were made with the plates S omitted on both sides, so as to have the bars cast directly against the face of their chillers, as displayed in Fig. 8. Here both bars remained in close contact with their chillers until cooled to a dark color. In casting these bars air of about 50 lb. pressure was admitted to one side only, passing down the pipe W and escaping at the lower exits seen at X, and thence passing upward to the external atmosphere through the space I. It was a surprise to find that this method proved practically no more effective than that just described. These tests appear to confirm those illustrated in Fig. 11 by demonstrating that there is a limit to which the thickness of a chiller affects its efficiency, and that its efficiency can not be assisted by artificial means. They forcibly illustrate the fact that if little or nothing is to be gained by holding a casting in close contact with a cooled chiller until it becomes of a dark color, it would be unreasonable to expect any benefit from a heat-absorbing medium passing rapidly through the internal body of a chiller or over its outer external surface when a space existed between the two.

CHILLING PRODUCED BY SAND-FACED MOLDS

37 It was desired to ascertain whether a chill could be created by air under pressure when prevented by a sand coating from getting directly at the hot surface of a casting. To this end the writer devised the method illustrated in Figs. 7, 13 and 14, the two last of which were experimented with at both foundries.

38 In using the mold shown in Fig. 7 an intervention core was employed, as seen on the left side. This core was about $\frac{1}{4}$ in. thick and well wired so that the head pressure of the molten metal could

not break it, when the plates R and S were pulled out together after pouring the molds. The first test of this series demonstrated the porosity of a sand mold's surface. Although this was a very hard core, the 50-lb. air pressure used carried the air through it and would have blown all the metal out of its mold had not the valve been closed. The companion bar withstood the air pressure for the reason that the plate S had formed a chilled crust on the face of the metal in the mold before its removal. Further tests with these cores under different air pressures showed that the cores prevented

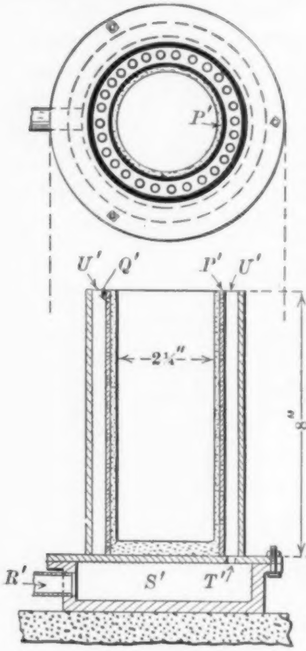

Fig. 13 Pipe Sand-Coated Air-Chilling Mold

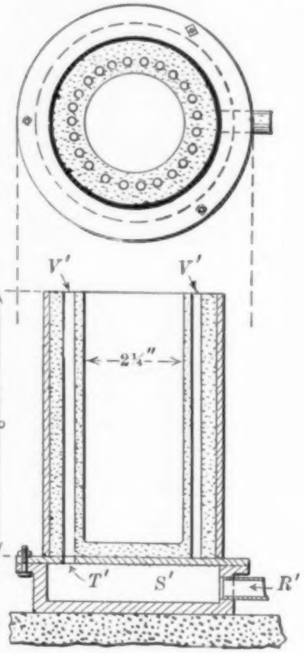

Fig. 14 All Sand Air Cooled Mold

any chilling action, while on the other hand the air was very effective on the opposite side.

39 The difficulty with this core method lies in the fact that air under sufficient pressure to penetrate the core and carry off heat in time to create a chill will pass clear through the metal when the latter is still in a liquid or semi-molten state. This led to the designing of the method seen in Figs. 13 and 14. By a study of the sand-coated pipe P', it can be seen that any pressure up to 200 lb. and

over can be employed without causing the air to impinge against the molten metal, while at the same time it can be more effective than the core itself in conveying heat to its outer surface and then to the atmosphere. The sand coating used on this pipe was but $\frac{1}{8}$ in. thick and thoroughly dried. To carry off the gases from the sand the iron pipe was closely perforated with $\frac{3}{32}$-in. holes as at Q'.

40 Air under 60 lb. pressure entered at R' to the chamber S' and passed up through the holes T' surrounding the pipe P'. The air in the chamber U' was free to absorb heat from the pipe P' and to carry it rapidly to the atmosphere. The molds were poured without any cope or covering, care being taken to fill them only within $\frac{1}{2}$ in. or so from their tops. In about 10 seconds after pouring the mold, the air was admitted and kept in action until all the metal was thought to have solidified. A fair illustration of results is seen at M', Fig. 10. An all sand molded, non-treated companion bar was always cast from the same ladle that poured the treated bar. A sample of this is seen at N' on the right of M'.

41 There is little doubt but that the pipe P' acted as a chilling agent without the use of air, as there was only $\frac{1}{8}$ in. thickness of sand between it and the face of the casting. In fact, a test made without the air showed that the pipe aided the chilling, since it gave a density to the crust of the casting. Again it is to be kept in mind that as the diameter of the casting was only $2\frac{1}{4}$ in., its contraction would not be sufficient to create a visible space between its outer body and the face of the mold, as is generally created in casting chilled rolls, car wheels, etc. Because a chill would be created by this method, as seen at M', is no positive evidence that air passing through the inside of a hollow roll or car wheel chiller, etc., would create a deeper chill.

42 In the all sand mold, Fig. 14, which was also dried, the air passed up through holes T', which were $\frac{1}{4}$ in. in diameter and about the same distance apart, all around the circumference, as seen by the plan view. The air escaped freely around the top at V'. The holes T' had but about $\frac{3}{16}$ in. thickness of sand between their inner exterior and the face of the mold. Castings produced by this method showed a dense exterior or crust of from $\frac{1}{8}$ in. to $\frac{3}{8}$ in. thick, and in some instances were slightly mottled. Only in one case was there any display of chill, and this was of an irregular character $\frac{1}{8}$ in. to $\frac{1}{4}$ in. thick, created inside of a gray crust about $\frac{1}{8}$ in. thick. In reality this was an example of inside chill, one of the factors sought

in these experiments being to learn if by such methods it could be produced at will and if it was controllable.

43 It was intended also to form holes as at V' with very thin pipes drilled closely full of $\frac{3}{16}$-in. holes, and if a steady pressure of 100 to 150 lb. of air could have been secured, further efforts to learn the practicability of obtaining an inside chill with such, or similar, methods would have been tried.

44 Study of the principle embodied in Figs. 7, 13 and 14 will suggest ideas and ways and means by which grades of soft iron, aside from chilling iron, can be made more dense or crust-hardened; also by which castings or sections of castings may be cooled to prevent contraction cracks and shrink holes.

EFFECT OF A JOINT, OR SPACE, ON TRANSMISSION OF HEAT

45 It is evident that in constructing chillers to be cooled by air, etc., sufficient consideration has not been given to the question of

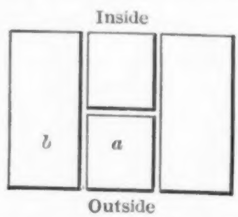

FIG. 15 ILLUSTRATING RETARDATION OF FLOW OF HEAT CAUSED BY JOINTS

transmission of heat. An excellent article by Carl Hering on The Flow of Heat through Furnace Walls[1] might be read with advantage in connection with this paper. Its author offers among other features the illustration seen in Fig. 15 with the following comments: "Moreover, the writer noticed recently in an electric furnace that the temperature of the brick at *a* in the sketch was considerably cooler than at *b*, the difference was so great that it was easily noticeable to the touch. This was no doubt due to the joint which separated the one from the inside of the furnace."

46 The principle illustrated in Fig. 15 is similar to that involved where such spaces exist as at K, Fig. 4, which greatly retard the absorption by the chiller of heat from the castings. It all emphasizes the utility of filling such a space as K with a heat-absorbing medium that can be moved swiftly from an inlet to an outlet to carry off heat for cooling, hardening or chilling purposes.

[1] Metallurgical and Chemical Engineering, September 1911.

47 It is believed that a study of the conditions will show that a rapid passage of air or other heat-absorbing media through a space as at *K*, Fig. 4, is very efficient for the purpose of extracting and conveying heat quickly both from the interior and exterior body of a hot casting.

TESTS ON HEAT CONDUCTIVITY OF SAND, IRON AND AIR

48 These tests were made for the purpose of ascertaining the heat conductivity of molds, composed of a sand body, and again of iron, as in chillers, instead of having a heat-absorbing medium impinge directly against the hot surface of a casting with exits for the rapid escape of the medium to the atmosphere.

49 The tests for sand conductivity were made by constructing a dry sand core $1\frac{1}{2}$ in. sq. by $7\frac{1}{2}$ in. long, with a $\frac{5}{8}$-in. port hole lengthwise through the center. This core had part of the outer face of one end cut away to provide an exit for the air forced through the interior of the core. When placed in position the core appeared practically like the chiller seen on the right of Fig. 8.

50 The tests for iron conductivity were made by having a chiller with solid face and other conditions of its position as seen on the right of Fig. 8.

51 In conducting these tests for the sand and iron, as well as with air impinging against the surface of the hot castings, only one end of the flask for twin molds was used. The mold *L* was formed with the same pattern, Fig. 5, as used for making all other bars. The molds were poured by a direct flow of the metal from the lip of the ladle. The top of the bars having been covered with sand and a plate to confine their heat so that the thermometer used would read correctly, the air-flow was started down the interior of the core or chiller and found an escape at the opening *X* and up the sides *I* to the top around *Y*, thence to the atmosphere, as in Fig. 8.

52 To obtain the temperature of the escaping air, the bulb of a thermometer capable of registering 500 deg. was held directly above and resting on the surrounding sides of the open space at *Y*. An assistant recorded the time and the varying temperatures of the escaping air at the first 15 and 30 seconds and afterwards each minute, as seen by lines 5 and 6 of Table 2. At the end of 10 minutes the bulb of the thermometer was held at one end of the inlet pipe after it was disconnected in order to obtain the record of line 4. At the end of 2 minutes, and after the plate and sand had been removed from the top of the bar, the bulb of the thermometer was placed so

that its frame end rested on the middle of the top end of the bar for 3 minutes, that the natural radiation of heat from the bar, seen in the last line of Table 2, might be recorded.

53 The variations in pressures and temperatures seen in lines 3 and 4 are due to changes in the speed of the compressors and to the amount of air being taken from the tank for other purposes. The seeming inconsistency of the temperature dropping at the start to only 80 deg. and 94 deg., while that which came from the tank of the compressors is 134 deg. and 124 deg., as in line 4, is due to the temperature of the core and chiller at the start being that of the atmosphere, as seen in line 2. For these reasons, the in-going air is for a few moments reduced in temperature.

TABLE 2 TEMPERATURE TESTS MADE OF THREE CASTS, OCTOBER 23, 1911

		Sand Core	Chiller	Face of Bar
1	Body cooled with air			
2	Temperature of atmosphere, deg. fahr	52	52	52
3	Pressure of air used, lb	55	50	50
4	Temperature of tank air, deg. fahr	134	124	130
5	Temperature escaping air at 15 sec	80	94	...
6	Temperature escaping air at 30 sec. deg. fahr	100	112	200
7	Temperature escaping air at 60 sec. deg. fahr	116	142	290
8	Temperature escaping air at 2 min. deg. fahr	120	162	310
9	Temperature escaping air at 3 min. deg. fahr	126	182	290
10	Temperature escaping air at 4 min. deg. fahr	130	182	270
11	Temperature escaping air at 5 min. deg. fahr	134	178	264
12	Temperature escaping air at 6 min. deg. fahr	136	176	252
13	Temperature escaping air at 7 min. deg. fahr	138	172	236
14	Temperature escaping air at 8 min. deg. fahr	140	170	222
15	Temperature escaping air at 9 min. deg. fahr	140	166	200
16	Temperature escaping air at 10 min. deg. fahr	138	162	192
17	Heat radiated from the bars 15 min. after they were poured, deg. fahr	208	172	70

54 A study of Table 2 shows the sand to be the least effective as a conductor of heat while the iron is not very much better when compared to the conductive power of air applied directly to the surface of the hot bar, as recorded in the last column, line 17, where it is seen that from the moment the air impinged upon the surface of the hot bars its temperature rose and in less than 30 seconds after the mold was poured reached 200 deg.

FURTHER EXPERIMENTS UPON DIRECT APPLICATION OF HEAT-ABSORBING MEDIA

55 The following experiments were largely responsible for patents granted May 1912 and pending on direct-cooling and treatment processes by pressure or suction for chilling, hardening reliev-

ing internal strains in castings, etc. These are to be utilized wherever a space can be formed adjacent to a casting, either artificially or by the natural expansion of the chiller and contraction of the casting, also when the hot surface of a casting is freely exposed to the atmosphere or not surrounded by its chiller.

56 Two twin molds were used for the experiments, each having intervention plates placed as at *S*, Fig. 7. After the two molds were poured from the same pouring basin, and a crust was formed on the face of the bars, the two plates were quickly and simultaneously removed from the mold, forming spaces as at *K*, Fig. 4. For the first experiments air of 20 lb. to 30 lb. pressure was admitted to one of the pipes, *W* Fig. 7, and conveyed directly to the space created by the removal of the plates *S* through orifices 1 to 8 in the bore of the chiller. The fast darkening of the top edge of the face of the treated bar, compared with that of the companion bar which was cooling naturally, gave good reason to expect considerable difference in the depth of chill and in the density or hardness of the chilled face of the two bars.

57 The intervention plates *S* were 2 in. wide by $\frac{1}{8}$ in. thick. A slight coating of oil was given the faces of these plates next the bars to prevent their uniting with the metal, and to permit their being drawn out of the mold quickly at the right moment.

EXPERIMENTS WITH COOLED AIR

58 Experiments were further made with air cooled by passing through a pipe coil surrounded by a mixture of two parts of cracked ice and one part of salt. The temperature was reduced thereby from 85 deg. to 45 deg. but no greater chilling effect was discovered in the six tests conducted on this plan than in the first series with the air as it came from the tanks. This is as would be expected, since the reduction of the temperature of the air by 40 deg. is so small in amount compared with the temperature of 2000 deg. which it may be assumed the surface of the molten bar would have. An increase in the pressure or volume of the air would easily discount all that could be accomplished by lowering the temperature of the air to 40 deg. as noted.

SUPERIORITY OF AIR OVER METAL CHILLERS

59 Tests were also conducted with air at higher pressures. At 50 lb. pressure a chill was created for a depth of $1\frac{1}{8}$ in. in the air-cooled bar, whereas the naturally cooled bar had a depth of chill of only $\frac{1}{8}$ in., as seen respectively at K' and L' in the bars G' and

H', Fig. 9. The gray body of both of these bars displayed a fine texture bordering on a mottled state. This test removed every possible doubt of the efficiency of air-cooling for chilling. Half a dozen or more of these tests were made before taking up others, and they all verified the results of the first tests.

60 Later on tests of the same character were conducted by having titanium and vanadium in the metal. Two sets of these samples are shown at *W'* and *X'* and again at *Y'* and *Z'*, Fig. 10. Here as in *G'* and *H'*, Fig. 9, the air was by far the most effective in chilling. The air-treated bars showed about $\frac{7}{8}$ in. depth of chill whereas their companions had but about $\frac{1}{8}$ in. chill.

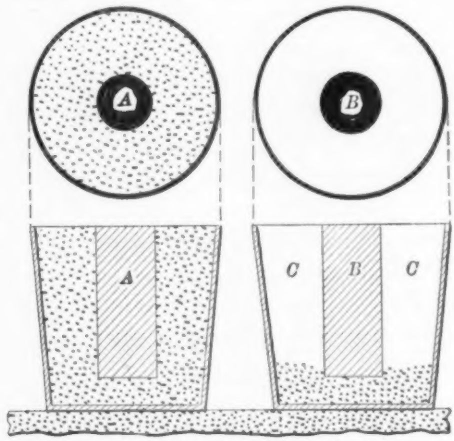

FIG. 16 SPECIMEN BAR CAST IN OPEN SAND AND AFTERWARDS FREED OF SAND AND SURROUNDED BY WATER

61 In line with these tests a series was made to determine whether air chilling was more effective than chilling by means of a solid chiller held in close contact with its bars. Samples of bars contrasting these two methods are seen at *I'* and *J'*, Fig. 9, the air-cooled bar at *J'* having $\frac{3}{4}$ in. chill, while the other at *I'*, produced by the close contact chiller bar, has $\frac{9}{16}$ in. chill.

62 Chilling of iron must be done before all the eutectic of the metal assumes a solid form or any graphite is formed, and with like irons the quicker and more penetrating the cooling action, the deeper and harder the chill. The direct application of a heat-absorbing medium to the surface of a hot casting, as soon as contact with its chiller is broken, or a crust is formed, provides means at a critical moment which can not but be of material benefit in

increasing the utility of cooling, densifying, or chilling and hardening of chillable and other grades of cast iron. It also provides means for securing a softer, or lower chilling and using a stronger iron in car wheels, etc., obtaining at the same time the desired depth of chill.

PRACTICABILITY OF CONTINUING CHILLING AFTER THE METAL SOLIDIFIES

63 It has always been thought that in chilling iron, the action ceased the moment the molten metal solidified. The writer's late experiments show that such is not the case; but that with chillable iron there exists a period of 20 to 30 seconds or more after the formation of a crust before any graphite is separated out. This was demonstrated as follows: At *A*, Fig. 16, is shown a casting poured in open sand, while at *B* it has been freed of its sand, this being done about $2\frac{1}{2}$ minutes after the casting was poured. Space *C* was then imme-

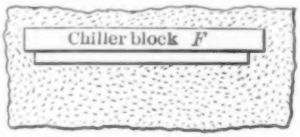

Fig. 17 Mold for Casting a Chilled Plate

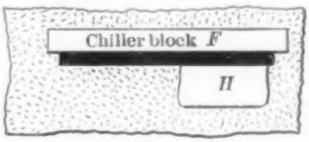

Fig. 18 Mold with Space *H* for Molten Metal

diately filled with cold water, kept running until the casting was cold.

64 Upon breaking the specimen it was found, if of a high chilling iron, to be a homogeneous body of all chilled or white iron with a discolored or reddish center. But if, instead of surrounding the specimen with water at the expiration of $2\frac{1}{2}$ minutes, there were allowed to lapse 3 to $3\frac{1}{2}$ minutes before doing so, the crust exhibited graphitic formation, while the interior body was found to exist in a mottled or all-white state, showing the inside chill to have been created.

TWO NEW PRINCIPLES IN CHILLING

65 These tests indicate the existence of two laws positive in their action, as follows: First, cooling or chilling is effective in creating or continuing a chill in a casting for a period of 20 to 30 seconds after its molten metal has solidified. This permits a continuation of chilling with castings like rolls and car wheels which break contact with their chillers immediately after the formation of their chilled crust. Second, graphitization having once taken place in the crust or body

of a hot casting, no sudden cooling can restore the carbon to its original combined form, and only by remelting can it be so transformed as to have a chilled or white iron structure.

DIFFICULTIES ENCOUNTERED IN CREATING AN INTERNAL CHILL

66 With chillable irons any founder can produce a casting having an outside chill with a gray interior, but to produce one having a gray exterior and inside chill, or white body, is another proposition.

67 Mention has already been made of the sensitive nature of such a production. The variable conditions that must be considered and controlled to an exactness in order to create a perfect inside chill are as follows: (*a*) Temperature of the pouring metal;

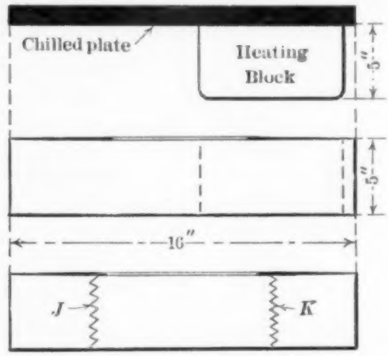

FIG. 19 CHILLED PLATE WITH HEATING BLOCK ATTACHED AND SEPARATED CASTING

(*b*) temperature of the sand; (*c*) atmospheric conditions and temperature; (*d*) nature of the iron; (*e*) size of the specimen; (*f*) temperature of the water; (*g*) whether the specimen remains stationary in its mold to be cooled or is removed or moved about in a body of water.

68 When it is stated that, for an example, with the size of specimen seen in Fig. 1, there are only some 5 to 10 seconds during 1 minute when the perfect inside chill can be created, all students of this problem will realize that at present it is a hit-and-miss process. The writer has deemed it necessary to give all the above facts, so that anyone undertaking to produce an inside or internal chill will not be led to affirm it an impractical achievement. It will be well to state that the writer is of the opinion, that when one can obtain a medium chilling iron in place of the extremes, such will be best for creating an internal chill.

INTERNAL CHILLING TESTS WITH HIGH SILICON AND SOFT CASTING MIXTURES

69 Tests made by the writer, assisted by Mr. W. J. Strangward, superintendent, at the Forest City Foundry & Manufacturing Company, Cleveland, Ohio, showed that the high silicon in their light work mixtures caused graphitization to take place almost immediately, if not at the moment, of solidification, as the specimens exhibited no white or even mottled internal structure in any of the tests.

70 Other tests made at the Madison Foundry Company of Cleveland, upon supposed non-chilling mixtures with silicon around 2.0 and sulphur under 0.08 showed that these percentages of silicon and sulphur marked the division between chilling and non-chilling irons of the usual good working grade of foundry mixtures. The tests showed that if internal chilling could be produced with mixtures having from 2.0 to around 3.0 per cent silicon, there was a possibility that something was wrong with the physical or the chemical properties of the mixtures.

71 A feature of these tests with soft irons was that they showed a swelling in place of a shrinkage in their taps; also a greater fluidity of metal, or length of time before solidification took place. Although these bars were but about $1\frac{1}{2}$ in. in diameter they remained in a liquid state about as long as specimens $2\frac{1}{4}$ in. in diameter cast of the chillable car wheel metal.

STANDARDS FOR INTERNAL CHILLING TESTS OF HARD AND SOFT GRADES OF IRON

72 Founders and engineers interested in castings for machining, etc., might well utilize internal chilling tests as a means of determining whether there is anything in the chemical or physical properties of mixtures likely to cause chilled edges, hard spots, etc., instead of waiting for this to be found out in the machine shop.

73 The writer would suggest as a standard for such tests, bars $1\frac{1}{2}$ in. in diameter and 6 to 8 in. long for mixtures ranging from 1.25 to 3.5 per cent silicon and bars 2.4 in. in diameter of similar length for mixtures having from 0.5 to 1.25 per cent silicon.

74 In making internal chilling tests care must be exercised not to immerse a specimen in water until a self-supporting crust has been formed, or an explosion of liquid metal may occur. The use of a fair amount of intelligence and caution will guard against such dangers.

INTERNAL GRAPHITIZATION OF A CHILLED CRUST

75 Being desirous of knowing whether, after the greatest depth of a chill is created, it is possible for the intense heat of an internal body of semi-molten or solid metal to decrease the depth of a chill by graphitization, the writer conducted the following experiments: An open sand mold having a chiller block *F* was used, as seen in Fig. 17. The open sand mold was formed by plate patterns $\frac{5}{8}$ in. and $\frac{7}{8}$ in. respectively, both being about 5 in. deep and 16 in. long. After the plates were poured and solidified, a space was dug out for about half their length, as seen at *H*, Fig. 18. This space was filled with molten metal, left in close contact with the chilled plates until cooled to a dark color. The molten metal was of regular car wheel mixture, and the tests were conducted at the National Car Wheel Company's plant, Cleveland, Ohio.

76 Tests were made with the plates at different temperatures from that at which the molten metal would fuse the face of the plate, down to temperatures at which the plates were of a dark color. Upon removing these plates and body blocks of metal from the molds, the chilled plates would be separated from the blocks of metal and broken at about the points *J* and *K*, Fig. 19, to display any contrast that might exist due to the treatment. Only in one case was the plate inseparable, and in this instance the plate and block were broken by a heavy drop block.

77 In all of these experiments a drawing of the chill in depth was displayed by reason of the hot molten metal causing a graphitization of the chilled face abutting it. The experiments made with the hottest plates showed the greatest effect, and such as to produce about a 25 per cent graphitization of the chilled plates face that abutted the hot metal. This effect was exhibited by a fairly uniform decrease of the graphitization down to the coldest plates, which showed but a slight effect of the treatment.

TESTS OF CHILLABLE IRONS

By Thos. D. West

ABSTRACT OF PAPER

The tests given in this paper relate to the relative strength of gray iron and of partly or wholly chilled iron, showing the best combination in chilled castings. Many tests are presented of chillable iron alloyed with vanadium and titanium.

Previous to these tests experiments were made for the purpose of establishing a size of round bars suitable for making tests of chillable irons where it is necessary to have the bars either of a uniform gray structure throughout or capable of being chilled throughout, the metal in each case being poured from the same ladle.

The effect is shown on the results of tests of different methods of locating the bar in testing with regard to the quality or grain of the metal. Attention is called to the advisability of drop tests for cast iron and to the complexity and sensitiveness of chillable iron mixtures, requiring delicacy in mixing, melting, casting and testing.

TESTS OF CHILLABLE IRONS

By Thos. D. West, Cleveland, Ohio

Member of the Society

The paper presents an original series of tests of chillable irons, made during September 1911 to the close of February 1912.

2 Before proceeding with the tests it was desired to find what size of bar should be used with different grades of iron to produce a bar of all gray iron and at the same time a companion bar that could be wholly chilled, or of a white iron, both poured from the same basin or ladle. Sets Nos. 1 and 2 show that bars $1\frac{5}{8}$ in. in diameter are suitable for various grades of chillable metal having its silicon ranging from 0.90 to 1.20. The balance of the sets show $2\frac{1}{4}$ in. diameter bars to be suitable for many grades having a range of 0.50 to 0.90 per cent silicon. It is to be understood that in either of the above the constituents, other than silicon, are generally the same as used in the making of such castings as chilled car wheels and rolls. In some cases the larger bars may be used for higher silicon metal, this depending chiefly upon the metal being high in sulphur and no ferro-manganese being used.

3 While the round bar is advocated for a standard, it is to be understood that there are cases of experimental work such as presented in this paper, where square bars may be advisable, but for ordinary practice to obtain comparisons in mixtures, grades of metal, etc., the round bars are to be preferred.

4 For molding the square bars three flasks were constructed, each being adapted to cast three or four bars. These bars were 2 in. sq. by 24 in. long. For casting the round bars, two chiller molds having a bore of $1\frac{5}{8}$ in., later on bored out to $2\frac{5}{16}$ in., were used in connection with two pipe sand molds. The designs for both are seen in Figs. 1 to 6 in the paper, A Suggested System of Test Bars for Chillable Irons, to be presented by the writer before the Sixth

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

Congress of the International Association for Testing Materials in September 1912. The three sets of flasks were often necessary, as in the case of making bars to test the relative effects of vanadium and titanium as alloys.

METHODS FOR OBTAINING AND ALLOYING METALS TO TEST THEIR EFFICIENCY

5 In casting sets for these tests, the bars were poured with the regular metal from a reservoir ladle under the cupola spout, with a capacity of about 7 tons, and carried to the molds in a "bull ladle" which held about 250 lb. Twelve ounces of ferro-manganese was thrown into the ladle, in order to secure the same composition as used for car wheels where 2 to $2\frac{1}{2}$ lb. of ferro-manganese is added to every 700 or 800 lb. of metal.

6 After the bars were poured of this regular wheel metal the bull

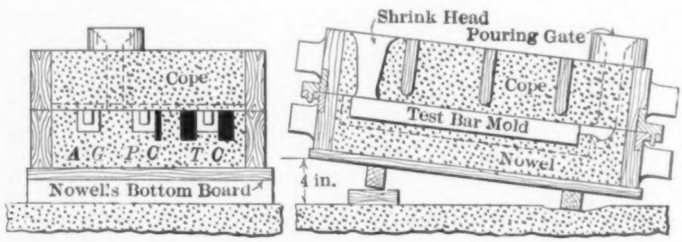

Fig. 1 Sectional Views of Mold for making the Square Test Bars

ladle was again filled as often as needed and vanadium or titanium, or both together, added according to the tests to be made, along with the 12 oz. of manganese. The ladle was allowed to stand for three or four minutes to permit the alloys to melt thoroughly and mix with the metal. A $\frac{1}{2}$-in. rod was used to agitate the metal to help bring any oxides created by the alloys to its surface. The two, three or more bull ladles of metal required for a set were taken from the reservoir ladle before any additional tap of metal was run into it from the cupola.

METHOD OF CASTING AND CHILLING THE ALLOYED METAL

7 In pouring either of the above alloyed metals with the regular metal to obtain a set of square bars, a set of round bars would be poured with the same ladle.

8 In casting the square test bars, some had a 2 in. by $2\frac{1}{2}$ in. chiller on two sides, as illustrated at *TC* in the end view of Fig. 1, so as thoroughly to chill the bar to make it all white iron. Others

had a wrought plate $\frac{1}{4}$ or $\frac{1}{2}$ in. thick as desired, on one side of the bar only, as at *PC*, in order only partly to chill one side of the bar. Bars to be free of chill, were surrounded with sand as seen at *AG*. In some cases two totally chilled bars and one all gray bar might be cast in the one flask. Again, two partially chilled, one totally chilled, and one all gray bar might be cast in one flask. This order could be changed in providing for three to four bars being made in a flask.

9 The character of the chill, or grain of iron, is given in the tables under the heading Fracture. Should an all sand molded bar show

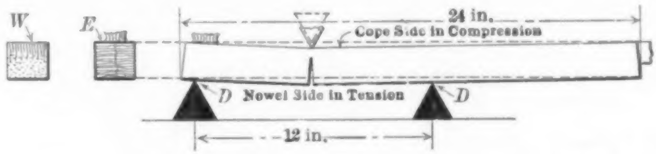

FIG. 2 END AND SIDE VIEWS OF A TEST BAR MADE IN MOLD, FIG. 1
W shows Gray Side in Tension and Strong Position; *E* shows Horizontal Plane of Chill Crystal in Tension and Weak Position

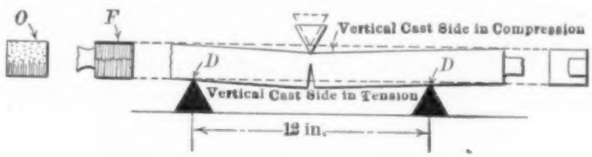

FIG. 3 SECOND TEST ON A 2-IN. SQ. BAR
O shows Chilled Side in Tension and Weak Position; *F* shows Vertical Plane of Chilled Crystal in Tension and Strong Position

a slightly mottled grain in its fracture instead of being all gray, the words slightly mottled are inserted. Should the fracture be strongly mottled the notation is the word " deeply " in the place of " strongly." In cases where the depth of a partly chilled bar was measured the thickness of the chill is given in connection with the statement that one side was chilled.

10 To indicate that one of the vertically cast sides, also the cope surface, or the nowel face of a bar is in tension when testing a bar, the words nowel, cope and side are placed on the line with the respective bar in the column headed Tension. This will be better understood by referring to Figs. 2 and 3 where the side and end view of the bars are shown in two ways of being tested. In the case of round, as well as square bars that are cast on end, as were Nos. 84

and 88, it makes no difference which way they are placed on the distance supports *D*, Figs. 2 and 3, when being tested.

11 The width and depth as well as the diameter of all the tested bars are given in Tables 3–10 to permit a checking of the modulus of rupture column; also present data for other formulae for computing variations in the size of the bars shown. It is to be understood that the records of all tests given are of solid bars and complete fractures; as should there have been a slight flow in any of those tested it would have been in the compression face of the bar where it could have no effect in reducing its strength.

METHODS USED FOR TRANSVERSE TESTING AND PRACTICABILITY OF DROP TESTS

12 All transverse tests on both round and square bars, Tables 5 to 9, except tests 59 and 77, were made with a 12-in. span, and all drop tests of Table 10 with an 8-in. span; all others were tested

TABLE 1 RANGE OF CHEMICAL ANALYSIS FOR CHILLED CAR WHEELS

Silicon	Sulphur	Manganese	Phosphorus	Combined Carbon	Graphitic Carbon
0.55 to 0.65	0.100 to 0.150	0.55 to 0.70	0.270 to 0.320	0.60 to 0.70	2.70 to 2.90

for the transverse and drop test on a 12-in. span, as seen in Figs. 2 and 3. Tests 59 and 77 were made with a 10-in. span. All drop tests of Tables 5 to 9 were made with a 12-in. span and all drop tests for Table 10 were made with an 8-in. span.

13 The drop tests were made with a 25-lb. weight having the first drop at a height of 6 in. and raised 6 in. higher for every blow until breaking the bar. If for example, 6 is the number in the drop column of the tables, it means that the weight dropped once at each of the respective heights, 6 in., 12 in., 18 in., 24 in., 30 in., and 36 in., before breaking the bar. The bars for the drop tests Tables 5 to 9 were obtained by taking the long end of the 24-in. long square bars after they had stood one transverse test. This is why two kinds of tests with the same bar are given under the same test number.

14 A comparison of the drop tests with the transverse tests shows that where a bar is strong transversely it generally shows a relatively high strength under the drop test. This was also true in the case of nearly all of the round bars having a 6-in. span, but these tests are not given herein.

15 For castings that are subject to shock or sudden impact, such as car wheels, rolls, shears, dies, etc., the drop test should grow in favor. The apparatus costs little and the time required is less than that needed in any other method of testing.

TREATMENT AND ANALYSIS OF REGULAR CAR WHEEL AND ALLOYED METALS

16 No special complete analysis is given of the respective sets

TABLE 2 ANALYSIS OF SETS ALLOYED WITH VANADIUM AND TITANIUM

Set No.	Oz. of Vanadium in 225 Lb. of Metal	Oz. of Titanium in 225 Lb. of Metal	Per Cent of Vanadium in Test Bars	Per Cent of Titanium in Test Bars	Per Cent of Manganese in Test Bars
9	10	..	0.06	....	0.63
11	..	10	....	0.02	0.72
13	22	..	0.12	....	0.64
15	..	22	....	0.07	0.60
18	5	10	0.04	0.03	0.69
19	8	15	0.05	0.05	0.68

TABLE 3 TRANSVERSE TESTS 1¾ IN. SQ. AND 1⅝ IN. ROUND BARS AND CRYSTALLIZATION

Test No.	Fracture	Width	Depth	Tension	Maximum Load	Deflection	Modulus	Set No.
1	All white	1.73	1.72	Nowel	5140	0.016	18070	1
2	All white	1.68	1.69	Side	13160	0.028	49380	1
3	Slightly mottled	1.75	1.76	Side	15300	0.060	50820	1
4	All white	1.59	diameter	....	4780	0.023	36280	1
5	Slightly mottled	1.60	diameter	....	7340	0.065	54670	1
6	All white	1.69	1.69	Nowel	7580	0.028	28260	2
7	All white	1.71	1.71	Side	15280	0.042	55010	2
8	Strongly mottled	1.72	1.79	Side	11940	0.038	39000	2
9	All white	1.60	diameter	....	5820	0.032	43350	2
10	Almost white	1.56	diameter	....	5540	0.040	44520	2
11	All white	1.59	diameter	....	3080	0.021	23370	3
12	Strongly mottled	1.58	diameter	....	7760	0.073	60030	3

other than that in Table 1. This is owing to the fact that car wheel mixtures or analyses, from one foundry at least, vary but little. Table 2 gives the vanadium and titanium constituents of the test bars. Analyses of metal taken directly from the reservoir ladle before the ferro-manganese was added showed this metal to contain around 0.40 manganese. The drillings for regular car wheel metal

analyses are taken from blocks about 2 in. by $2\frac{1}{2}$ in. by 8 in. cast in all sand so as to leave a gray body in the metal, which will agree closely with the gray between the plate and body back of the chill of a car wheel.

SENSITIVE CONDITIONS REQUIRING CONSIDERATION AND CONTROL IN TESTING CHILLABLE IRONS

17 Table 3 shows that bars $1\frac{3}{4}$ in. square and $1\frac{5}{8}$ in. round are too small for regular car wheel metal. This is seen by the all-sand bars 3, 5, 8, 10 and 12, showing a fracture a little too strongly mottled instead of a fair gray structure. These sizes of bars are recommended only for chillable irons ranging from 0.90 to 1.20 per cent in silicon for use in general practice.

18 The foregoing is a general statement requiring modifications in some instances. A comparison of the strength of bars 4, 5, 11 and 12 with 9 and 10 shows the cases in which strongly mottled iron of the same metal, also iron tending to all white, as No. 10, will give exceptional strength. Many other round bars $1\frac{5}{8}$ in. in diameter were made, but broken with the sledge to check these fractures. The two odd bars 11 and 12 are shown chiefly to demonstrate the distinction they display.

19 When a bar is of such a size that it is sensitive to assume a mottled form, it is very likely to go further and become almost white, and with the same iron, temperature of metal and character of mold, there is as much chance to obtain a strength of 7760 lb. as 5540 lb., as seen for bars 10 and 12. But this sensitive condition must be avoided in order better to make comparisons between an all-chilled bar and an all sand cast one of the same size, form, and metal. To do this, it is necessary to have the sand cast bars sufficiently large to prevent their taking a mottled form, and still not so large as to prevent their being absolutely chilled, or all white iron to their very center, when cast in an all-iron mold or chiller of the same diameter. Much experimenting may often be necessary to learn to know the best size to adopt for making a comparison between the white and gray of special chillable irons. It will be seen by the tables having the $2\frac{1}{4}$-in. round bars, that even with this increase over the $1\frac{5}{8}$ in. in diameter, some of the larger bars show a slightly mottled fracture with the silicon around 0.60. This could have been largely avoided by baking or drying the sand molds, as those used in the tests shown were all of green sand. To increase the size of the round bar would assist this feature, and such could be done to the extent of having it

$2\frac{3}{4}$ in. and possibly 3 in. in diameter and still produce a perfect, all-chilled bar for a companion to an all sand cast or gray one having the silicon around 0.60.

20 It is important therefore to describe the structure of fractures when recording tests of chillable iron and in making comparisons with all-chilled and gray bars or otherwise. It all shows that in some cases, it may be necessary to experiment in order to obtain the diameter best suited to give a knowledge of the relative strength of

TABLE 4 TRANSVERSE TESTS OF VARIABLE DEPTHS OF CHILL WITH LOW CHILLING IRONS

Test No.	Fracture and Per Cent of Chill	Width	Depth	Load	Deflection	Modulus	Set No.
13	Not chilled; clear gray iron	1.01	1.51	5615	0.098	43900	4
14	Chilled one side; 10% white	1.00	1.50	4360	0.085	34900	4
15	Chilled two sides; 25% white	0.96	1.44	3270	0.056	29600	4
16	Not chilled; clear gray iron	0.98	1.46	5175	0.105	44500	5
17	Chilled one side; 15% white	1.03	1.48	4220	0.069	33700	5
18	Chilled two sides; 20% white	1.02	1.45	4390	0.079	36900	5
19	Not chilled; clear gray iron	0.97	1.47	5000	0.103	43000	6
20	Chilled one side; 1% white	1.00	1.47	5610	0.108	46750	6
21	Chilled two sides; 100% white	1.01	1.47	6400	0.080	52800	6
22	Not chilled; clear gray iron	1.00	1.46	4350	0.157	36700	7
23	Chilled one side; 5% white	0.99	1.43	4550	0.159	40500	7
24	Chilled one side; 20% white	1.06	1.50	4200	0.137	31700	7
25	Chilled two sides; 50% white	1.02	1.50	2300	0.110	18050	7

the white and gray of chillable irons. This does not prevent the adoption of a standard to be used the world over[1] for tests for chillable irons. All that is necessary is to state the structure of the fracture, diameter of the bar used, per cent of silicon, and possibly other constituents, should they vary much from those given in Table 1.

ERRATIC EFFECTS OF CHILLED CRYSTALS AND INTERLACING OF THE GRAY WITH THEM

21 Table 4 presents a few of the many tests made with chillable metal, having about the following composition: silicon 2.0, sulphur 0.06, phosphorus 0.04, manganese 0.30. The bars were made in a

[1] Suggested by the author in a paper, A Suggested System of Test Bars for Chillable Irons, prepared for the Sixth Congress of the Int. Assoc. for Testing Materials for their meeting, to be held Sept. 1912.

TABLE 5 BARS 26 TO 30 HAD 12 OZ. MANGANESE; 31 TO 34, 12 OZ. MANGANESE AND 10 OZ. VANADIUM IN 225 LB. OF METAL

Test No.	Fracture and Per Cent of Chill	Width	Depth	Tension	Load	Deflection	Modulus	Drop	Set No.
R 26	Chilled both sides. All white iron	2.04	2.00	nowel	15150	0.030	33420	4	8
R 27	Chilled ½ in. one side	2.10	2.05	nowel	14330	0.036	29230	6	8
R 28	All gray iron	2.12	2.08	nowel	23860	0.070	46820	9	8
R 29	All gray iron	2.31	diameter	....	25750	0.095	63710	..	8
R 30	Chilled. All white iron	2.21	diameter	....	14620	0.030	41330	..	8
V 31	Chilled two sides. All white iron	2.08	1.97	nowel	16100	0.030	35900	4	9
V 32	Chilled ⅝ in. one side	2.05	1.99	nowel	15370	0.035	34080	5	9
V 33	All gray iron	2.08	2.00	nowel	22020	0.070	47640	9	9
V 34	All gray iron	2.32	diameter	....	23430	0.070	57300	..	9

Set *R* poured with regular iron. Set *V* poured with vanadium in regular iron. Set *T* poured with titanium in regular iron.

TABLE 6 BARS 33 TO 39 HAD 12 OZ. MANGANESE; BARS 40 TO 44, 12 OZ. MANGANESE AND 10 OZ. TITANIUM IN 225 LB. OF METAL

Test No.	Fracture and Per Cent of Chill	Width	Depth	Tension	Load	Deflection	Modulus	Drop	Set No.
R 35	Chilled both sides. All white	2.14	1.98	nowel	22420	....	48108	..	10
R 36	Chilled $\frac{7}{16}$ in. one side	2.03	2.07	nowel	18990	0.037	39170	3	10
R 37	All gray iron	2.12	2.04	nowel	25740	0.075	54700	11	10
R 38	All gray iron	2.27	diameter	....	25520	0.077	66570	..	10
R 39	Chilled. All white iron	2.22	diameter	....	13440	0.024	37477	..	10
T 40	Chilled both sides. All white	2.02	1.97	nowel	16100	0.031	36960	4	11
T 41	Chilled ⅜ in. one side	2.07	2.00	nowel	15130	0.032	33280	5	11
T 42	All gray iron	2.06	1.99	nowel	21870	0.074	48250	9	11
T 43	All gray iron	2.32	diameter	....	23400	0.059	57180	..	11
T 44	Chilled. All white iron	2.22	diameter	....	17110	0.028	47711	..	11

TABLE 7 BARS 45 TO 49 HAD 12 OZ. MANGANESE; BARS 50 TO 54, 12 OZ. MANGANESE AND 22 OZ. VANADIUM IN 225 LB. OF METAL

Test No.	Fracture and Per Cent of Chill	Width	Depth	Tension	Load	Deflection	Modulus	Drop	Set No.
R 45	Chilled both sides. All white	1.90	2.02	nowel	16460	0.030	38220	5	12
R 46	Chilled ⅜ in. one side	2.10	2.00	nowel	14380	0.035	30810	7	12
R 47	All gray iron	2.08	2.01	nowel	23790	0.090	50960	11	12
R 48	All gray iron	2.29	diameter	....	23910	0.078	60730	..	12
49	Chilled. All white iron	2.22	diameter	....	15610	0.022	43520	..	12
V 50	Chilled both sides. All white	2.00	1.98	nowel	16030	0.035	36800	4	13
V 51	Chilled $\frac{7}{16}$ in. one side	2.10	2.02	nowel	14090	0.030	29600	3	13
V 52	Gray, slightly mottled	2.05	2.00	nowel	24800	0.065	54440	7	13
V 53	Gray, slightly mottled	2.27	diameter	....	25580	0.060	66710	..	13
V 54	Chilled. All white iron	2.20	diameter	....	17890	0.025	51250	..	13

TABLE 8 BARS 55 TO 59 HAD 12 OZ. MANGANESE; BARS 60 TO 64, 12 OZ. MANGANESE AND 22 OZ. TITANIUM IN 225 LB. OF METAL, WHILE BARS 65 TO 68 WERE FREE FROM MANGANESE AND OTHER ALLOYS

Test No.	Fracture and Per Cent of Chill	Width	Depth	Tension	Load	Deflection	Modulus	Drop	Set No.
R 55	Chilled both sides. All white	2.00	2.00	nowel	15980	0.030	35960	4	14
R 56	Chilled ⅜ in. one side. Balance mottled	2.00	2.07	nowel	18140	0.038	38100	4	14
R 57	Gray iron. Corners chilled	2.02	2.00	nowel	22720	0.070	50610	7	14
R 58	Gray iron, slightly mottled	2.25	diameter	....	26000	0.075	69640	..	14
59	Chilled. All white	2.24	diameter	....	13830	0.017	33966	..	14
T 60	Chilled both sides. All white	2.00	1.98	nowel	13200	0.025	30300	4	15
T 61	Chilled ½ in. one side. Balance mottled	2.04	2.03	nowel	16840	0.035	36060	4	15
T 62	Gray, corners slightly chilled	2.05	2.00	nowel	22080	0.075	48470	10	15
T 63	Gray iron	2.26	diameter	....	25810	0.08	68230	..	15
T 64	Chilled. All white iron	2.22	....	....	16070	0.05	44810	..	15
S 65	Chilled both sides. All white	2.04	2.04	nowel	11400	0.020	24170	3	16
S 66	Chilled ⅝ in. one side. Deeply mottled	2.06	2.04	nowel	10860	0.030	22800	3	16
S 67	Gray, corners mottled	2.04	2.00	nowel	17870	0.050	39420	5	16
S 68	Gray iron, mottled	2.25	diameter	....	24180	0.065	64204	..	16

Set *S* poured with spurious metal containing no ferro-manganese.

TABLE 9 BARS 69 TO 72 HAD 12 OZ. MANGANESE; BARS 73 TO 77, 10 OZ. TITANIUM AND 5 OZ. VANADIUM; BARS 78 TO 82, 12 OZ. MANGANESE, 15 OZ. TITANIUM AND 8 OZ. VANADIUM IN 225 LB. OF METAL

Test No.	Fracture and Per Cent of Chill	Width	Depth	Tension	Load	Deflection	Modulus	Drop	Set No.
R 69	Chilled both sides. All white	1.98	2.02	nowel	18480	0.035	41170	5	17
R 70	Chilled ¼ in. one side. Balance mottled	2.04	2.50	nowel	16760	0.055	23660	6	17
R 71	All gray iron	2.05	2.05	nowel	24390	0.085	51020	11	17
R 72	All gray iron	2.27	diameter	....	24030	0.065	62660	..	17
*TV*73	Chilled both sides. All white	2.02	2.00	nowel	12330	0.025	27470	..	18
*TV*74	Chilled ⅜ in. one side. Balance mottled	2.05	2.07	nowel	18340	0.040	37580	6	18
*TV*75	All gray iron	2.10	2.04	nowel	24980	0.065	51390	11	18
*TV*76	All gray iron	2.29	diameter	....	22070	0.060	56060	..	18
*TV*77	Chilled. All white iron	2.21	diameter	....	16370	0.029	38560	..	18
*TV*78	Chilled both sides. All white	1.96	2.03	nowel	16250	0.030	36210	4	19
*TV*79	Chilled ¼ in. one side. Balance mottled	2.00	2.04	nowel	14580	0.040	31530	5	19
*TV*80	All gray iron	2.04	2.00	nowel	22240	0.065	49060	8	19
*TV*81	All gray iron	2.29	diameter	....	23470	0.060	59620	..	19
*TV*82	Chilled. All white iron	2.20	diameter	....	18700	0.030	53570	..	19

converter steel foundry and tested by John H. Nelson; all others were tested by H. E. Smith. In testing this set, the load was applied in the deep direction of the bars which were all cast on end. Tests 13 to 25 illustrate the erratic qualities of partly chilled bodies, accounted for by the interlacing of the white with the gray and the depth of mottled iron back of the chilled body.

22 In partly chilled sections, the temperature of the chiller to chill the iron, and of the metal to pour the mold, and the degree of dampness in the sand, have an effect both on the depth of chill, and on the structure of the metal for a considerable distance beyond the place where the white ceases. These are all factors difficult to control in regular practice, but the more that is known concerning them, the better will be the design, make and use of the castings. The variable hardness of mottled and gray bodies, interlacing with the white iron of chilled bodies, are displayed by the hardness tests, Table 12.

TRANSVERSE AND DROP TESTS OF GRAY AND CHILLED BARS ALLOYED WITH VANADIUM AND TITANIUM

23 Tables 5 to 9 present an original series of tests comprising the following features:

- *a* Comparison of strength, deflection, chill and contraction, in all-chilled, partly-chilled, and gray bars of the same metal.
- *b* Comparison of square and round bars to emphasize the utility of the latter for a standard.
- *c* Comparisons of transverse and drop tests to show their conformity, and practicability of the latter.
- *d* Comparisons of hardness created by the rate in cooling, giving chilled, mottled and gray fractures in the same metal.
- *e* Effects of ferro-manganese, vanadium, and titanium in the same metal and size of section, when of a chilled, mottled and gray structure.

24 Results of the above comparisons in connection with those to be derived from a study of the tables are given throughout the paper.

NOTABLE DIFFERENCE IN THE STRENGTH OF THE CHILLED AND GRAY SIDES OF A PARTLY CHILLED CASTING

25 It will be seen from tests in Table 10 that when the chilled face is in extension, as with Tests 92, 94 and 96, the casting is much

weaker than when the gray or mottled body is in extension, as with Tests 91, 93 and 95 of Set 22. This is a quality having heretofore received very little, if any, thought. When fully considered it will be seen to be of great importance in the making and use of different lines of castings. The reliability of this set of tests will be realized when it is understood that the respective companion tests having the chilled side in compression and tension were made

TABLE 10 TRANSVERSE AND DROP TESTS OF ONE SIDE CHILLED BARS ALTERNATED TO BE IN COMPRESSION AND TENSION

Test No.	Fracture and Per Cent of Chill	Width	Depth	Load	Deflection	Modulus	Drop	Set No.
83	Gray iron, slightly mottled	2.09	2.06	21070	0.045	42760	7	20
84	Chilled four sides. All white	2.12	2.18	23380	0.040	41770	15	20
85	Chilled 5/8 in. one side. Balance mottled. Gray side in tension	2.06	2.05	21590	0.030	43435	9	20
86	Chilled 5/8 in. one side. Balance mottled. Chilled side in tension	2.07	2.03	20430	0.035	43111	7	20
87	Gray iron, slightly mottled	2.11	2.07	19420	0.045	38664	8	21
88	Chilled four sides. All white	2.06	2.20	22450	0.020	40532	15	21
89	Chilled 11/16 in. one side. Balance mottled. Gray side in tension	2.10	2.04	19880	0.050	40947	8	21
90	Chilled 11/16 in. one side. Balance mottled. Chilled side in tension.	2.06	2.06	13660	0.030	28132	6	21
91	Chilled 1/4 in. one side; 3/4 in. mottled. Gray side in tension	2.11	2.15	23760	0.070	43861	14	22
92	Chilled 1/4 in. one side; 3/4 in. mottled. Chilled side in tension	2.13	2.06	17260	0.035	34373	..	22
93	Chilled 1/4 in. one side; 3/4 in. mottled. Gray side in tension.	2.12	2.10	21760	0.055	41914	7	22
94	Chilled 1/4 in. one side; 3/4 in. mottled. Chilled side in tension.	2.13	2.06	13190	0.025	26378	..	22
95	Chilled 1/2 in. one side; 1 in. mottled. Gray side in tension.	2.11	2.03	20350	0.055	42127	5	22
96	Chilled 1/2 in. one side; 1 in. mottled. Chilled side in tension.	2.13	2.13	15720	0.030	29281	..	22

with the same bar, by the method shown in Figs. 2 and 3. After making two transverse tests of the same bar, there was sufficient remaining for a drop test having an 8-in. span. A few of these are Tests 83 to 96. Bars 83 to 90 were cast on end, while bars 91 to 96 were cast flat, as shown in Fig. 1, and chilled on one side only to give two of this form for one set. In Fig. 6 is seen a full set of the square bars cast on end, in which *M* is the all chilled bar, *N* the chilled side, and *O* the gray side of the partly chilled bars, while *P* is the all sand cast bar. The position of the chilled face

in the testing is shown at *W* for both the cast on end and cast flat bars when upward, and at *O* when downward, seen on the left of Figs. 2 and 3.

26 Another feature is the great difference between the strength of chilled iron when the lines of crystallization stand vertical to the load, and when they are turned horizontal to it. In Table 3, Tests 1, 2, 6 and 7 show a difference of about 61 per cent for the first two bars, and about 51 per cent for the second two. The lines of crystallization are seen in Figs. 2 and 3, where *E* is the weakest and *F* the strongest position of the two-sided bar. These qualities were original-

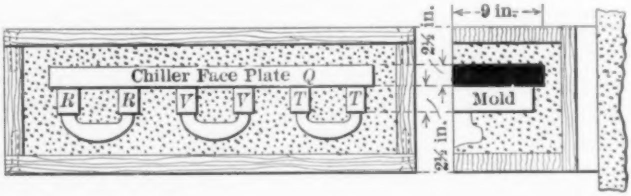

FIG. 4 OPEN SAND MOLD FOR MAKING COMPARATIVE CHILLING TESTS

ly discovered by Asa W. Whitney, and are presented here to give data in keeping with the original tests of this paper.

CRITICISM ON AND CHILLING EFFECTS OF VANADIUM AND TITANIUM

27 William H. Hatfield in a paper On The Influence of Vanadium upon Cast Iron [1] at the March 1911 meeting of the Iron and Steel Institute, stated, "There is considerable disagreement as to the influence of vanadium." Expressions of this character had much weight in the taking of extra precautions when testing these alloys, in the belief that the results might settle some of the disputed points.

28 Information of the chilling qualities of the alloys is given in Pars. 29 to 31 and in the various sets of Tables 5 to 9, as Tests 27 and 32. It required but a few tests to show that the difference in the pouring temperature of the metals, due to the cooling effect produced in melting the alloys, was such as to make the depth of chill shown in Tables 5 to 9 an uncertain factor for these tests. This is more fully realized when the fact is considered that "hot" metal will chill deeper than "dull" metal.

29 To obtain more favorable conditions for rapid pouring and less travel of metal than was offered by the mold, Fig. 1, cupola chill

[1] The Journal, Iron & Steel Institute, vol. 83, no. 1, p. 318.

blocks were made after the plain and end views in Fig. 4. The pair of chilled blocks *R* were poured with the regular car wheel metal, cooled down to nearly the same temperature as that for pouring the chill block molds *V* and *T* having the vanadium and titanium alloys in their respective ladles. This method emphatically demonstrated that the vanadium increased the depth of chill, or held the carbon more in its combined form, while the titanium operated in the opposite direction. Numerous tests were made following this plan, some of

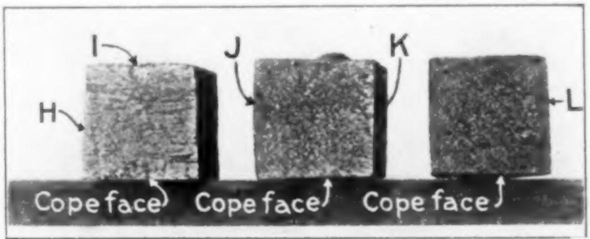

Fig. 5 Set of All Chilled, Partly Chilled and All Sand Square Bars Cast Flat

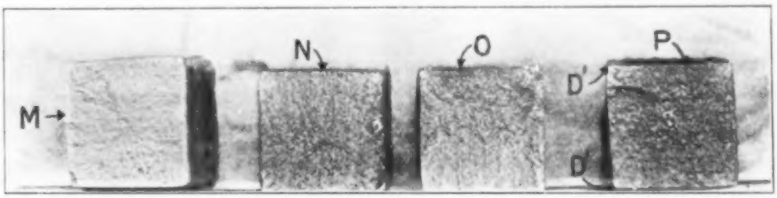

Fig. 6 Set of All Chilled, Partly Chilled and All Sand Square Bars Cast on End

which had a $\frac{1}{2}$-in. chiller face plate in place of the $2\frac{1}{2}$-in. plate *Q*, and all of them were effective in the same direction as to their respective results.

30 One test with the three sets of molds, Fig. 4, gave a difference in the thickness of chill as seen at *X*, *Y* and *Z*, Fig. 7. The Set *R* was poured with the regular iron; the Set *V* with the vanadium and the Set *T* with the titanium alloyed metal, there being 1 lb. of each alloy in about 175 lb. of metal.

31 Further experiments having 2 lb. of titanium in the 175 lb. of metal gave a thickness of chill seen at *V* and *W*, Fig. 7, of 1 in. and $\frac{1}{2}$ in. respectively as marked in the cuts. In the belief that by

increasing the amount of titanium the chill might be wholly prevented, 4 lb. was put into the metal for two tests. This did not act as effectively as the 2 lb. and showed that iron could not be prevented from chilling beyond a certain limit by its use.

EFFECTS OF VANADIUM, TITANIUM AND OTHER FACTORS ON CONTRACTION

32 Tests to obtain contraction were made with both round and square bars and are given in Table 11. The $2\frac{1}{4}$-in. round bars show the contraction for a length of 12 in. and the square bars for 22 in. The ratios for contraction of the bars cast on end agree closely with those of the bars cast flat. The regular irons are fairly uniform in

TABLE 11 CONTRACTION OF ROUND BARS CAST ON END AND SQUARE CAST FLAT

Set No.	Round Bars, All Chilled	Round Bars, All Gray	Square Bars, All Chilled	Square Bars, Part Chilled	Square Bars, All Gray
R 12	0.22	0.12	0.47	0.28	0.26
V 13	0.23	0.13	0.48	0.30	0.27
R 14	0.22	0.12	0.47	0.28	0.26
T 15	0.21	0.11	0.43	0.29	0.25
S 16	...	...	0.50	0.36	0.32
R 17	...	...	0.48	0.31	0.28
TV 18	0.22	0.12	0.47	0.29	0.26
TV 19	0.23	0.12	0.48	0.30	0.27

their contraction. The vanadium bars show a greater contraction than those containing titanium, the latter having the least of any of the metals. The spurious metal of Set 16 having no ferro-manganese in it, shows the greatest contraction. The most radical difference exists between the all-chilled and all gray bars.

EFFECTS OF VANADIUM AND TITANIUM ON STRENGTH

33 In making deductions of the relative strength for the alloy mixtures, etc., the round bars were selected chiefly on account of their uniform structure and greater uniformity of results. Fig. 8 is a good illustration of the uniformity of the metal as it comes in round bars rather than in square ones. The gray round bar A' shows a much better uniformity of grain structure than exists in the square bars L and P, Figs. 5 and 6. These last present irregular patches of grains embodying every structure from white at the corners D', interlaced with mottled, leading to a gray center, sensitive to change with the least variation in the dampness or character of the sand, hardness in ramming and temperature of pouring metal. This irregularity

of structure is likewise apparent in the all white square bars *H* and *M*, Figs. 5 and 6, when compared to that seen at *B'*, Fig. 8.

34 The titanium bars show an increase of strength over the regular bars of 27 per cent in the white iron with bars 39 and 44, Table 6, and 32 per cent in the white iron with bars 59 and 64, Table 8.

35 The vanadium shows an increase of strength of 9 per cent in the gray iron, with bars 48 and 53, and 17 per cent in the white with bars 49 and 54, both of Table 7.

36 The spurious bars which have no ferro-manganese or other alloys in them, show a decrease of strength of 7 per cent in the gray

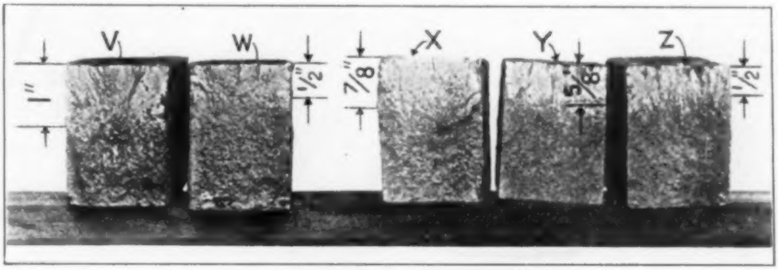

Fig. 7 Specimens affected by Cooling and Varying Percentages of Vanadium and Titanium

iron, with bars 63 and 68 of Table 8. No comparison of the white iron in the round bars can be given, since there are no chilled round bars for this last set; but the contrast is so great in the square chilled bars 55 and 65, which show the white of the spurious metal, that it is safe to consider them 30 per cent weaker than the regular iron.

37 Some tests having shown vanadium and titanium beneficial in increasing the strength, it seems reasonable to suppose that all the other sets having them alloyed in the regular metal should show a similar tendency. It may be that in car-wheel metal there is a definite absorption of the alloys necessary to increase materially the strength of the gray and white. By the use of large round test bars for making the relative comparison in these irons, further experimenting with this grade of metal along practical lines should establish beyond any doubt the question of such a limit.

COMPARISON OF PARTLY CHILLED WITH WHOLLY CHILLED AND GRAY BODIES

38 In conducting this series of tests, bars were cast having only

one side chilled as companion bars to the all-chilled and gray bars, as seen by the second test, Tables 5 to 9. It will be a surprise to many to find that in all the tests, excepting the two of Set 14, the partly chilled bars are weaker than the all-chilled or white bars. A good view of these three companion bars is shown in Fig. 5, *K* being the partly chilled side.

39 The weakness of the partly chilled bars is due to internal strains and scattered amalgamation of the state of the broken carbon of the metals. Bars showing nearly every effect of rapid and slow cooling, and in no wise possessing the homogeneous blending of one character of grains, seen by the wholly white and gray, is well illustrated by *H*, *L*, Fig. 5.

40 All the partly chilled bars showed the chilled body interlac-

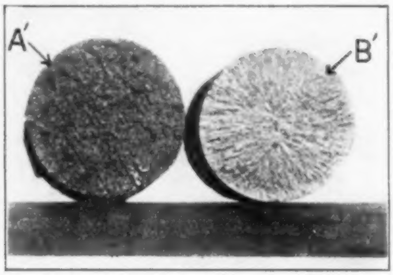

Fig. 8 Specimens of All Chilled and All Sand Round Bars Cast on End

ing the mottled, and the latter blending into the gray, Figs. 5, 6 and 7. This is generally considered to be a stronger section than those where a distinct line marks the separation of the white and gray, and causes conditions such as can still further increase the weakness of partly chilled castings. Designers should duly consider this factor, so as either to have a strong backing of the mottled and the gray, or to have the chilled side of the casting arranged in compression if practical, when strains or concussions of its work is brought to bear upon it, a feature in keeping with the tests on treatment of Table 10.

COMPARISON OF STRENGTH IN ALL WHITE AND ALL GRAY IRONS

41 A feature of this paper worthy of consideration is the strength and deflection obtainable in strictly all-chilled or white iron. It is generally supposed that white iron is very much weaker than gray, and has very little if any deflection. By referring to Tests 7, 21, 30,

35, 44, 49, 54, 69, 82, 84 and 88, it will be seen that white iron can be obtained at least 75 per cent as strong as gray. White iron is the strongest with the crystals radiating from a center as at *M* and B,′ Figs. 6 and 8. The round bar excels the square in this form of structure.

SPALLING WEAKNESS OF CHILLED OR WHITE IRON

42 The chief evil of white iron lies in its strength being erratic, and easily spalled. It is believed that founders could greatly increase and control the strength of various grades of white irons and make them much more reliable.[1]

43 Numerous experiments were conducted to test the spalling weakness of white and gray iron and it was found that white bodies do not possess much over one-third the strength to resist spalling blows that exists in the gray or mottled of the same iron. It shows the importance of designing that portion of the casting subject to such blows to contain as far as practical gray or mottled iron.

HARDNESS TESTS OF ALL CHILLED, PARTLY CHILLED AND SAND-CAST TEST BARS

44 Table 12 gives Brinell and Scleroscope tests of three samples taken from each of the first three bars of Sets 12 to 19, a view of which is seen in Fig. 5. The Brinell depressions were produced by a $\frac{3}{8}$-in. ball loaded with 6000 lb. and the readings are the weight in kg. sustained by 1 mm. of area of the depression produced by the total load. This is the standard method of testing Brinell hardness. Both the Brinell and Scleroscope records are the averages of 4 to 6 tests on a sample.

45 The columns *H*, *I*, *J*, *K* and *L* give the tests of the surfaces indicated by the same letters shown in Fig. 5. Those who conduct these kinds of tests know that there is some variation of hardness over an area although it may not exceed 1 sq. in. The surfaces *H* had a variation of 3 to 7 points and *I*, 8 to 15 points, *J* about 6 points, while *L* had but 3 points, showing that a greater uniformity in hardness can be expected in all gray bodies than in mottled or chilled surfaces.

46 The table also shows that directly chilled faces, as *H*, are harder than those crystallizing over a sand surface caused by the heat-absorbing effect of a chiller, some distance from such points, as *I*. The excessive variation of the surface *I* is believed to be caused by the curved structure of the heat radiation lines, as they come to

[1] See foot-note, p. 871.

the surface at an angle, differing from the straight lines shown on the sides at *H*.

47 The spurious iron is on an average harder than the regular iron. The alloys appear to have a hardening effect as compared with the regular iron, or that having only ferro-manganese in it. The irregularity in the effect of the alloy is no doubt due to the variations in the temperature of the metal filling the molds, and brings about variations in hardness similar to creating an irregularity in the chill, strength, deflection and contraction of like irons.

CREDIT FOR PROFESSIONAL COÖPERATION

48 Nearly all the bars tested for records in this paper were cast at the Cleveland plant of the National Car Wheel Company, and

TABLE 12 BRINELL AND SCLEROSCOPE HARDNESS TESTS OF SPECIMENS, FIG. 4

Set No.	Class	*H*		*I*		*J*		*K*		*L*	
		Bri.	Scl.	Bri.	Scl.	Bri.	Scl.	Bri.	Scl.	Bri.	Scl.
12	*R*	394	65	348	59	179	39	326	55	185	39
13	*V*	377	63	358	60	227	41	403	60	199	41
14	*R*	417	66	403	58	185	38	386	61	175	38
15	*T*	419	68	427	56	211	41	412	58	186	40
16	*S*	452	69	412	59	224	40	443	60	191	42
17	*R*	358	62	390	56	189	39	317	47	173	37
18	*TV*	382	64	375	61	193	40	400	54	183	40
19	*TV*	442	66	422	54	189	41	417	57	179	38

tested by Mr. H. E. Smith, engineer of tests, assisted by Mr. G. E. Doke, both of the Lake Shore & Michigan Southern Railroad, Collinwood, Ohio. Assistance was rendered in making the bars by Messrs. H. E. McClumpha, general manager; J. D. Cunningham, plant manager; and Charles K. Logue, foreman of the wheel foundry. Some of the tests shown herein were made by Prof. John H. Nelson of the Case School of Applied Science. The hardness tests were made by Mr. Robt. R. Abbott, metallurgical engineer of the Peerless Motor Car Company; the analyses by Messrs. Crowell and Murray, chemists, both firms of Cleveland. The vanadium was furnished by Mr. George L. Norris, engineer of tests of the Vanadium Sales Company of America, and the titanium by Mr. Charles V. Slocum, general sales agent of the Titanium Alloy Manufacturing Company, both of Pittsburgh, Pa. All the test bars were made by the writer and tested under his supervision, who hereby desires to tender sincere thanks to all the above firms and gentlemen for having so kindly and ably assisted him in these researches.

BITUMINOUS COAL PRODUCERS FOR POWER

By C. M. Garland

ABSTRACT OF PAPER

The paper describes the apparatus and general arrangement of bituminous coal producers as designed for power. The scrubbing apparatus is described in detail, data given on its efficiency, and the amount of solid matter delivered in the gas. Data on the efficiency of the plant, composition of the gas, and operating costs, together with brief discussions on these items are also included. Figures for the first cost and operating costs at full load for a 1200-b.h.p. plant are given in such a way as to make them applicable to different conditions of fuel and load.

BITUMINOUS COAL PRODUCERS FOR POWER

By C. M. Garland, Camden, N. J.

Member of the Society

In the development of the power producer for the gasification of fuels containing above 12 per cent volatile matter, the manufacturers at an early date divided themselves on the question of the method of handling this troublesome constituent and proceeded with their developments along two diverging lines.

2 In one they sought to convert the condensible combustible constituent of the volatile matter into fixed combustible gases by drawing this product through either the whole or part of the incandescent fuel remaining after volatilization; in the other to separate the condensible portion from the permanent gases after these had left the generating chamber. The former group accordingly turned their energies to the development of down-draft and double-zone arrangements, while the latter bent their efforts toward the production of efficient up-draft generators and tar-handling apparatus.

3 It has been the fortune of the writer to observe the operation of a number of plants of the latter type and to analyze the results of the operation of others. It is the object of this paper to present some of the data accumulated, which are necessarily more or less fragmentary in character.

DESCRIPTION OF APPARATUS

4 The plants are all of two general types, suction and pressure, while the apparatus is essentially similar in each, varying principally in size and general arrangement. Fig. 1 shows a vertical section through the producer, scrubber and the water-sealed gas main, which is characteristic of the arrangement of all later plants up to about 1000 h.p. capacity. The pressure plant differs from the

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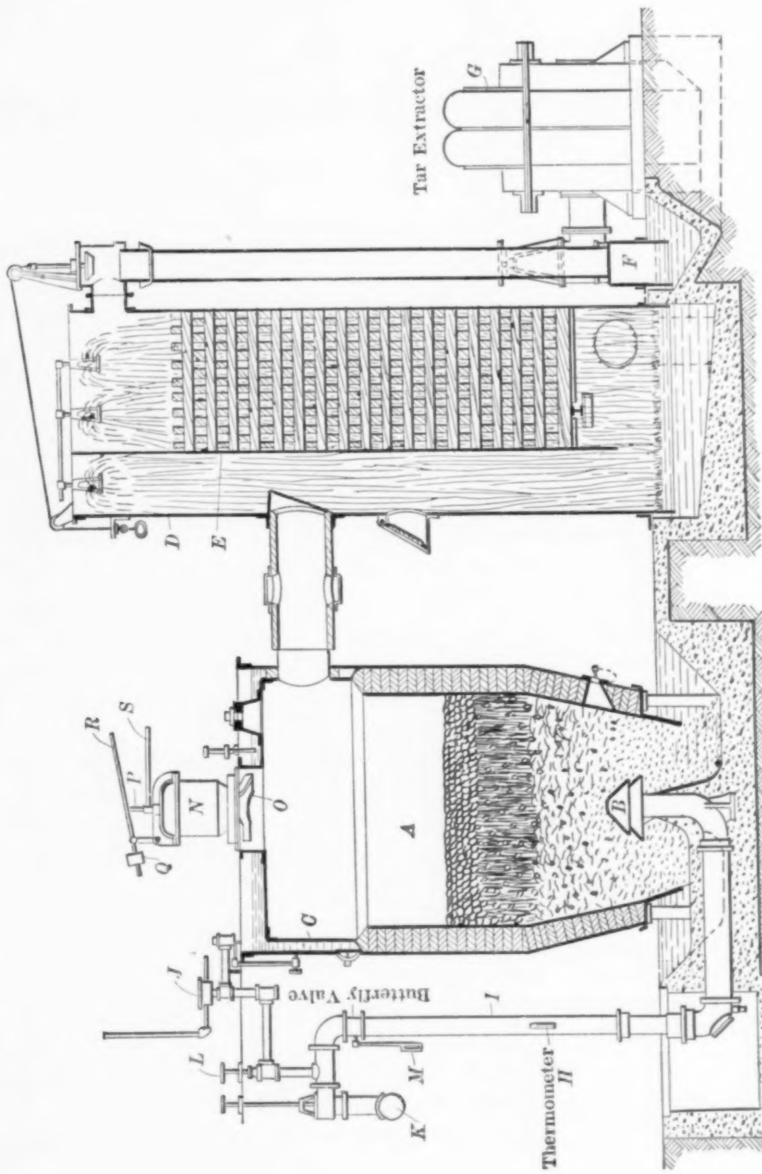

FIG. 1 SECTION OF GAS PRODUCER PLANT FOR POWER

suction plant by the addition of a fan type blower, frequently installed in duplicate, and a regulating holder. This latter in the earlier plants served as a large storage reservoir with capacity sufficient to keep the engines operating from 3 to 10 minutes in cases of emergency. It was also thought that this large capacity tended to insure greater uniformity in the composition of the gas supplied to the engines, so that the holders were placed in series with the engine and scrubbers. In more recent plants the size of the holder has been greatly reduced and in most cases floats on the line so that the gases do not pass through this piece of apparatus.

5 This change has been brought about partly by the fact that a large storage capacity is not required and in many places is undesirable. Also the mixing effect of the gases in the holder has proved a fallacy.

6 From Fig. 1 it will be noted that the producer *A* is of the water-sealed type, with central blast *B* and superimposed vaporizer *C*. The gases pass direct from the producer to the scrubber *D*, which is provided with a vertical baffle *E* from the scrubber to the water-sealed main *F*, and from this to the tar extractor *G*. This latter piece of apparatus is of the centrifugal type and is illustrated in Figs. 2 and 2a. The extractor has been in use a number of years and was brought out by Mr. F. V. Matton of the Camden Iron Works.

7 Referring to Fig. 2, the gas enters at *A* and meets a stream of water at *B*. The mixture flows upon the rotating vanes *C* and is discharged into the stationary vanes *D*. The water and a portion of the tar is thrown out against the casing *E* and follows this around to the drain *F* which discharges into the seal pit *G*. The gas leaving the stationary vanes *D* re-enters the rotating vanes *H* on the opposite side of the disk *I*. The gas here meets a stream of water from the nozzle *J* moving in the direction opposite to the gas which removes the remaining tar. The gas leaves at *K*.

8 The extractors are usually designed to deliver the gas under a low pressure and are built in more than one stage for the larger powers.

9 A portion of the steam generated in the superimposed vaporizer *C* in Fig. 1 is used to saturate the blast. The amount supplied is indicated by the temperature shown on the thermometer *H*, which extends into the blast pipe *I*. The steam pressure on the vaporizer is maintained constant by the back pressure valve *J*,

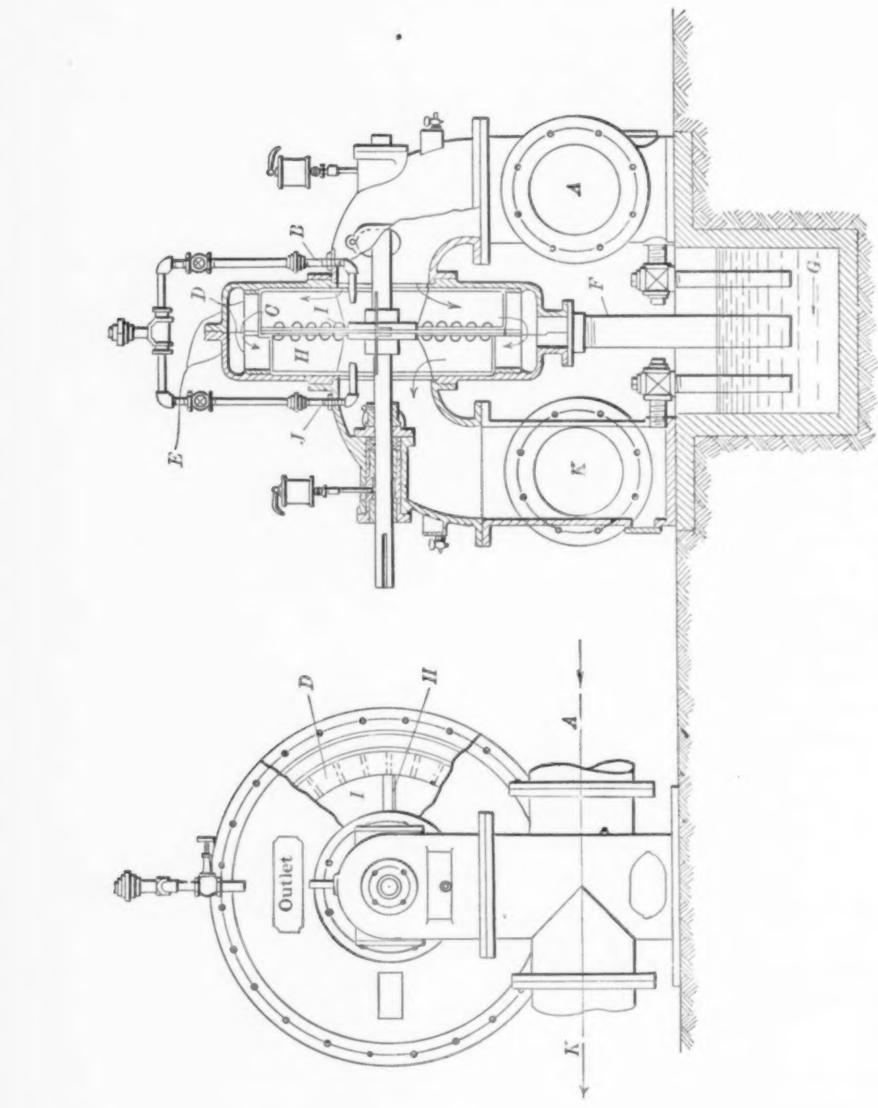

FIG. 2 175-H.P. TAR EXTRACTOR

while the air pressure on the main *K* is also constant. The valve *L* is therefore used to vary the amount of steam delivered to the blast. The butterfly valve *M* connects with the holder and regulates the amount of blast delivered to the producer. Changes in the position of this valve do not affect the relative proportions of air and steam. In more recent plants a thermostat located in the blast pipe operates a throttle valve in the steam line from the vaporizer in order to maintain a constant temperature of the blast.

10 The fuel is fed to the producer by the hand-operated centrifugal charging device *N*, which insures a very even distribution of fuel. This consists of the hopper provided with the ribbed charging bell *O*, which is rigidly mounted on the shaft *P* and held against its seat by the counterweight *Q*. When the fuel is charged the bell is lowered by the arm *R* and at the same time rotated by the arm *S*. Both arms are hand operated. After the fuel is charged, the counterweight *Q* causes the bell *O* to seat. A sliding cover closes the top of the hopper which prevents the escape of gas while dropping a charge of fuel.

11 With this brief general description it will not be necessary to describe a number of individual plants. In order, however, to indicate the extent and variety of the work, Table 1, giving the equipment, service, load conditions, etc., has been prepared from a number of representative plants operating on different fuels.

THERMAL EFFICIENCY OF THE PRODUCER

12 The efficiency depends to a certain extent upon the amount of volatile matter contained in the fuel. For fuels containing as high as 30 to 50 per cent of volatile matter, the thermal efficiency based on the higher heating value of the gas is about 66 per cent, while the efficiency based on the effective heating value of the gas is ordinarily 5 per cent lower than this, or 62.7 per cent. Where the volatile matter does not exceed 20 per cent the efficiency is somewhat higher, and 70 per cent based on the higher heating value of the gas is an average figure. The lower value is approximately 66.5 per cent.

13 In plants of the present type, however, thermal efficiency is not necessarily of paramount importance, for more often it is a question of the adaptability of the producer to a given fuel or to several fuels and of continuity and reliability of operation.

TABLE 1 BITUMINOUS COAL AND LIGNITE PLANTS

Plant	*A*	*B*	*C*	*D*	*E*	*F*	*G*
Type of plant	Suction	Suction	Pressure	Pressure	Suction	Suction	Pressure
No. of producers	1	1	3	2	2	1	2
No. of tar extractors	1	1	2	2	1	1	2
Inside diameter of producers, ft.	7	6	8	6	7	5	7
Spare producers	0	0	1	1	0	0	0
Spare tar extractors	0	0	1	1	0	0	1
Size of holder, cu. ft.	...	...	5000	5000	...	...	15,000
Rated capacity of plant, b.h.p.	225	140	900	190	500	125	500
Character of service	Light and power	Light and power	Light and power	Light and power	Mill	Pumping	Light and power, gas for heating
Years plant in operation	2	2½	1½	6½	3	2	5
Hours per day in operation	11	18–24	24	...	10–24	10–24	24
Days per week in operation	6	6½	6½	...	6½	6½–7	6
Load factor, per cent	About 100	...	Variable	...	Variable	About 100	About 100
Character of load	Uniform	Variable	Variable	Variable	Variable	Uniform	Uniform
Fuel used	Illinois coal	* Various	Pocahontas	Pocahontas	Lignite	Lignite	Pocahontas New River
Proximate analysis fuel:							
Fixed carbon, per cent	55.30	32.10	73.70	71.40	16.4	29.39	...
Volatile, per cent	35.47	47.00	17.7	21.70	51.2	39.84	...
Moisture, per cent	3.00	3.90	1.6	2.20	25.7	23.11	...
Ash, per cent	6.23	17.00	7.0	4.70	6.7	6.78	...
B.t.u. per lb.	13,500	11,000	14,700	14,700	8,500	...	14,700

* Texas bituminous coal used when determining solid matter in the gas.

COMPOSITION OF THE GAS

14 The composition of the gas and the heating value are comparatively uniform where proper attention is given to the operation of the producers. Table 2 shows the gas analyses taken on a seven-day test, which was made on the plant marked *C* in Table 1. The calorific values by the calorimeter, taken every two hours, are plotted in Fig. 3. The average higher heating value of the gas was 144.1 b.t.u. per cu. ft. at 62 deg. fahr. and 30 in. mercury pressure. The average lower heating value was approximately 136 b.t.u. under

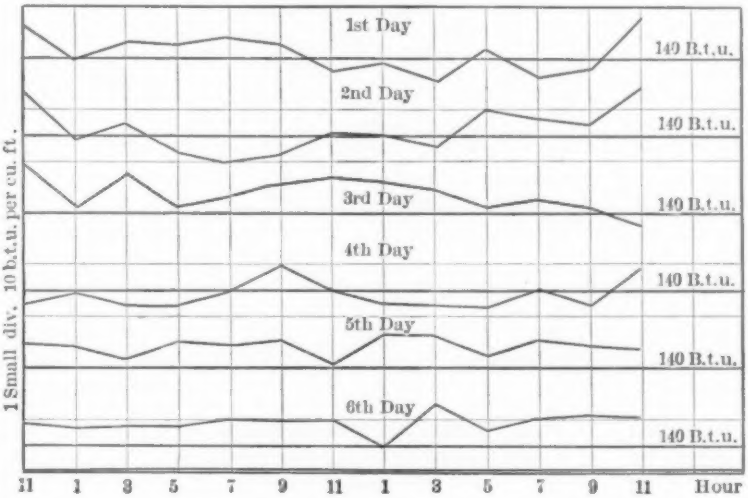

FIG. 3 HEATING VALUE (HIGHER) OF GAS FOR 144 HOURS CONTINUOUS RUN, PLANT *C*

the same conditions of pressure and temperature. For fuels containing greater percentages of volatile matter there is a tendency toward an increase in the calorific value of the gas due to the increase in hydrocarbons. With the lignites, for example, the higher heating value of the gas may average as much as 155 b.t.u. per cu. ft.

VOLUME OF GAS GENERATED

15 The volume of gas generated per pound of coal depends upon the composition of the coal and the condition of the fuel bed. In the seven-day test (Table 2), the volume of the standard gas generated per pound of run of mine Pocahontas coal was approximately

71.5 cu. ft. For lignite the volume of standard gas varies between 36 and 40 cu. ft. per lb.

TABLE 2 GAS ANALYSES, SEVEN-DAY TEST, PLANT *C*

Day	CO_2	O_2	CO	H_2	CH_4
1st*	5.6	0.2	24.1	7.65	4.5
	4.0	0.2	27.6	9.83	3.3
	6.8	0.4	22.6	10.36	2.0
	5.8	0.2	23.6	13.8	2.4
2d	8.2	0.3	17.5	11.3	3.4
	5.2	1.2	21.8	14.00	2.5
	4.5	0.2	25.9	13.40	2.2
	4.8	0.2	25.5	11.60	2.4
	4.6	0.4	26.3	10.60	2.4
	7.9	0.7	18.7	12.43	3.0
	5.4	0.3	24.5	8.50	2.2
	7.2	0.2	19.6	10.53	3.6
	7.3	0.1	20.1	10.30	2.9
3d	7.8	0.4	18.8	10.9	3.8
	5.2	0.4	24.0	11.4	2.6
	5.5	0.2	22.5	8.93	3.4
	5.5	0.2	22.5	8.93	3.4
	5.2	0.4	23.6	9.50	2.9
4th	5.0	0.4	23.6	10.80	2.3
	4.0	0.2	25.4	10.52	3.3
	4.6	0.2	24.2	9.60	3.3
	4.2	0.4	25.1	11.7	2.6
	4.7	0.0	25.8	12.0	2.6
	6.0	0.3	20.8	10.53	2.1
5th	3.5	0.2	25.5	9.50	2.6
6th	4.2	0.2	24.7	9.15	3.5
	5.0	0.3	24.7	9.40	3.8
7th	5.0	0.2	24.2	9.15	3.4
	4.9	0.3	24.8	11.03	2.0
	4.4	0.3	25.7	12.00	2.6
	4.9	0.3	25.0	12.0	2.0
	5.3	0.4	25.3	10.8	2.0
	4.5	0.3	25.6	9.8	2.2
8th*	4.0	0.2	26.	9.25	2.40
	5.5	0.3	24.3	11.45	2.0
	5.0	0.3	24.3	11.53	2.0

* One-half day only.

TABLE 3 TESTS ON CLEANLINESS OF GAS DELIVERED BY TAR EXTRACTORS

Plant	No. of Determinations	Fuel	Per Cent Volatile	Grains Solid Matter, Cu. Ft.	Efficiency Extractor, Per Cent
A	1	Illinois Coal	31.0	0.0150	96.0
B	2	Texas bituminous	47.0	0.0062	99.5
C	11	Pocahontas	17.7	0.0163	98.5
D	1	Pocahontas	21.7	0.0585	93.5*
E	2	Texas lignite	51.2	0.0050	99.5
F	2	Pocahontas	22.8	0.0227	....

* Tar extractors operated at 1000 r.p.m., instead of 1500 r.p.m. rated speed. Dry scrubber used beyond tar extractors in this plant; solid matter in gas leaving dry scrubber 0.0421 grains per cu. ft.

CLEANLINESS OF THE GAS

16 A large number of tests have been made on the cleanliness of the gas delivered by the tar extractors in the above plants. The

results of these determinations are given in Table 3. From these it will be seen that the amount of solid matter in the gas has been reduced to a very small quantity and averages 0.0206 grains per cu. ft. of standard gas. The efficiency of the tar extractor is given also in several cases. This was taken as the ratio of the weight of solid matter in the gas leaving the extractor, to the weight of solid matter in the gas entering the extractor, multiplied by 100.

17 The determinations were made by drawing samples of the gas through three thicknesses of filter paper on which the solid matter was deposited. In most cases simultaneous samples were taken from the entering and exit sides of the extractor. These samples were measured by calibrated meters.

18 It will be seen from the results of Table 3, that the average weight of solid matter per cubic foot of standard gas is not sufficient to cause trouble in engines of ordinarily good design. Experience seems to indicate that with 0.03 grains of solid matter per cu. ft. in the gas, the engine valves require cleaning once in two or three weeks. There is no trouble from this source in plants that are properly operated and the cleaning of the valves would not be considered a hardship.

19 In making the above determinations, no attempt was made to separate the tar from the dust, as this was not deemed of sufficient importance.

HANDLING OF THE TAR

20 In the earlier plants considerable difficulty was experienced by the tar accumulating in the scrubbers and pipe lines, which caused frequent shutdowns. In almost every case this trouble was due to lack of experience on the part of the builders in designing these parts, and to the operators who failed to take proper precautions and profit by their first troubles.

21 At the present time and for the more modern plants it can be safely said that trouble from this cause has almost entirely ceased. The water-sealed gas main has solved the piping difficulty, while refinement in the design of the other parts and close attention to detail has accomplished the same effect for these.

22 In so far as the yield of tar is concerned, there are but three objections that can be urged against this:

a Loss in efficiency of the plant due to the removal of a combustible constituent from the fuel.

b The expenditure of power in the driving of the tar extractor for the removal of this constituent.

c Difficulties in the disposal of the constituent.

23 Taking it for granted that the tar in every instance can be disposed of satisfactorily, as it can be, the answer to these objections is that it is entirely a question of economy and if it does not pay to handle this element then bituminous coal is either not the fuel to use, or a producer plant is not the kind suitable to the conditions.

24 The magnitude of the above items is fairly well known. The loss in thermal efficiency (*a*) varies from 12 per cent for fuels containing from 15 to 20 per cent volatile matter to 17 per cent for fuels containing above or near 30 per cent of volatile matter.

25 The amount of power (*b*) required to drive the tar extractor depends upon the nature of the tar produced. With lignites, for example, which produce a thin yellowish tar resembling very nearly a heavy oil, the power required is at least 25 per cent less than the amount required for bituminous coals.

26 For bituminous coals this power varies from 5 per cent of the power of the plant in a plant of 100 b.h.p. to about 3.5 per cent for a plant of 1000 b.h.p., and it is believed that this figure will be reduced almost one-half in the near future.

27 As to the difficulties in the disposal of the tar (*c*), there is in some instances a ready market for the tar product so that this may be disposed of to advantage. In other cases where boilers are in service, it can be burned without difficulty under these boilers.

28 The usual method of handling the tar is to place the extractor over a pit containing water into which the mixture of tar and water from the extractor is discharged. The pit is arranged so that the tar may be skimmed from this into a barrel or receiver. Where a receiver is used it is provided with an air tight cover, and when the receiver is filled the cover is put in place and either steam or air under pressure placed above the tar, which forces it through piping to the point of disposal. Where the tar is thick and heavy, it is necessary to provide the receiver with a steam coil to keep the tar in a fluid condition.

THE FUEL REQUIRED

29 It can almost be safely said that any fuel can be used in any well designed producer of the up-draft type. If the fuel can not be used the probabilities are that the fault is either in the operation or in the design of the producer. The reason for this is that there are

but three fundamental requirements for the successful gasification of a fuel. These are, uniform distribution of the blast, uniform distribution of the green fuel and uniform removal of ash. These three are essentially one as they are so closely related and interdependent that they reduce to uniform distribution of the blast.

30 When these requirements have been met in the design of the producer, the writer has never found a fuel that could not be gasified, at much higher rates and with much less labor than is considered possible by the majority of engineers.

31 An example in which the difficulty lies in the operation of the producer is illustrated in the case of the Texas bituminous coal, Plant *B*, Table 1. This was a highly caking coal and the operators of the producer stated that it was impossible to use this fuel in the producer. After observing the operation for a few hours it was found that the difficulty was due to the caking properties. When full hoppers of fuel were dropped upon the hot bed the fuel fused into a solid mass through which the blast could not penetrate. By charging a half hopper of fuel every 15 minutes in place of a full hopper every 30 minutes, there was no further difficulty.

32 The analyses of Table 1 indicate the variety of fuels that are being used successfully, and to these can be added Hocking Valley, Pittsburgh run of mine, Youghiogheny, etc.

RELIABILITY

33 Referring to Table 1, from the last reports obtained about one year ago, Plant *D* had been in successful operation for over five years without a shutdown and without having the fire drawn from the producers.

34 The last reports from Plant *A* indicated highly satisfactory results and no shutdowns, the engine pulling full load and a large portion of the time as much as 15 per cent overload. Fig. 3 shows the heating value of the gas taken every second hour for 144 hours continuous running, while Table 2 shows the analyses of the gases taken over the same period, from Plant *C*, Table 1. Two 8-ft. producers were in operation for the full period. The engines pulled an average load of 568 kw. with a maximum of 640 kw. for 1 hour, and a minimum of 405 kw. for 1 hour. The coal consumption was 1.78 lb. per kw-hr. at the generator terminals, including a 24-hr. standby, and the rate of gasification was about 10 lb. of coal per sq. ft. of fuel bed per hour. The fuel used was Pocahontas run of mine.

35 Plant *F* is used for irrigation work where the load is inter-

mittent. At times it operated at full load 24 hours per day and at other times only 10 hours per day. Results have been entirely satisfactory. The same is true of *E*, which operates a cotton meal mill. This is one of the most successful lignite plants. The latest reports state that lignite screenings, costing less than 50 cents per ton, are being used successfully.

36 Plant *G* showed a fuel consumption of 1.65 lb. of coal at full load per kw-hr. at the generator terminals, 1.89 lb. at three-quarter load and 2.2 lb. at one-half load, when operating on Pocahontas coal. On New River slack the coal per kw-hr. is approximately 1.6 lb. at about full load.

37 Plant *B* was reported unsatisfactory. It was found on investigation that for two years the plant had been operated from 18 to 24 hours per day and the station logs showed that the engine had pulled a 25 per cent overload for about 2 hours during the peak every evening. Any fuel that could be picked up in the open market was used, and the man that operated the producers also fired two boilers for running about 400 h.p. in high-speed steam engines.

PRODUCER PLANT COSTS

38 The cost of producer plants and of operating are by no means fixed quantities, so that it is very difficult to give figures that are general and that can be safely applied to any and every case. Each plant requires individual consideration in order that no mistakes or misunderstandings may arise. It is therefore with some hesitation that the following figures are given.

FIRST COST

39 The first cost depends upon

a The service or load conditions, that is, continuous, intermittent, or variable load, and the magnitude of the load. These determine the necessity for duplicate or spare apparatus and the number of units into which the plant should be divided.

b Upon the design of the producer. With a given fuel one type of producer may gasify 50 per cent more fuel than another type, or one type may be capable of continuous operation, while still another may require a light load during the period of the removal of ash.

c Upon the method of generating steam for the blast. That is, whether or not the producer generates its own steam

supply or requires that this should be generated in separately fired boilers, either direct fired or exhaust fired. Where the producer generates its own steam supply the first cost of the producer plant is, as a rule, much less expensive than the installation of either direct or exhaust-fired boilers.

d Upon the characteristics of the fuel. One fuel may be gasified at a much higher rate than another, thus reducing the size of the producers required.

e Upon the percentage of ash. With low percentage a plain water-sealed producer is satisfactory. With percentages above 12 or 15 per cent a rotating table and cone bottom become desirable in order to reduce the labor costs.

f Upon the scrubbing apparatus required. This depends upon the amount of volatile matter in the coal, and the characteristic of the products resulting from the volatile matter which appear in the gas.

g Upon the method of handling the coal.

h Upon local conditions.

OPERATING COST

40 The operating costs are very intimately connected with the first cost and depend upon

a The character of the fuel. Some fuels require a greater amount of labor than others.

b The design of the producer. A properly designed producer will require much less labor than a poorly designed producer when operating on a given fuel at a given rate of gasification. In some instances small changes in the arrangement of the admission of the blast to the producer have reduced the labor required to operate at least 50 per cent.

c The amount of ash contained in the fuel.

d The coal-handling machinery.

e Facilities for handling the tar.

f Supervision. In every instance where the plant is under the direction of a man that understands the apparatus and has given his thought to the operation, the operating costs are greatly reduced.

g Local conditions.

41 In order to analyze the different costs and indicate their

approximate magnitude for pressure plants ranging in size from 500 to 1500 b.h.p., a proposition will be assumed wherein it is required to develop from bituminous coal of known properties, approximately 1200 net b.h.p. in excess of the power required to operate the producer auxiliaries.

42 It will be assumed that the load conditions are such that three units are desirable and the costs will be based on full load operation 365 days per year, 24 hours per day. From these costs the effect of various load factors may be investigated.

43 The following assumptions will be made:

Coal.............13,500 b.t.u. per lb. calorimeter determination or high value	
Cost per ton delivered	\$1
Per cent volatile matter	32
Per cent ash	8
Efficiency of the producer based on the effective heating value of the gas, per cent	62.7
Effective b.t.u. required by the engines per b.h.p. at full load	10,500
Effective b.t.u. per lb. of coal $\dfrac{13500 \times 62.7}{100}$	8465
Lb. coal per b.h.p-hr. $= \dfrac{10500}{8465}$	1.24
B.h.p. required for tar extractor	30
B.h.p. required for fan blower	5
B.h.p. required for scrubber water pump	5
Total auxiliaries	40
Total b.h.p. required	1240
Total lb. coal per hour $= 1240 \times 1.24$	1538
Area of fuel bed required at 10 lb. gasification, sq. ft.	153.8
Three producers 8 ft. inside diameter will be required. These would have a continuous overload capacity of 25 per cent, and 50 per cent for three hours	
Area of fuel bed of each producer, sq. ft.	50.26

44 Each producer should be of the water-sealed type for continuous operation since the fuel is a bituminous coal of medium grade containing a fair amount of ash. The steam for the blast may be obtained by the use of a superimposed vaporizer, a vaporizer placed between the producer and the scrubber, an exhaust boiler or an independently fired boiler. The latter is very uneconomical and has a high initial cost, so that it is not used in power work at the present time. The exhaust boiler is economical provided there is no other use for the steam that may be thus generated. The first cost is, however, high, and as in many cases it must be located at a

distance from the producers and requires more or less attention, its use in plants of this size and for this purpose is hardly justifiable.

45 The vaporizer or boiler between the producer and scrubber, while an excellent arrangement for anthracite plants, is unsuitable for bituminous coal plants on account of the solid matter that is carried in the gas.

46 The superimposed vaporizer therefore remains as the last choice. This is low in first cost and while it absorbs a certain amount of radiant heat from the fuel bed, which could otherwise be utilized, it is convenient, requires little or no attention and essentially no repairs, so that for small and medium sized bituminous plants it is the most economical method of generating steam for the producers, and will therefore be selected.

47 To each producer a static scrubber will be connected, as shown in Fig. 1. These scrubbers will in turn connect to a water-sealed gas main. Since the plant is to operate continuously, two tar extractors and two fan blowers will be required, one of each for a spare. The tar extractors and fan blowers should be driven by electric motors direct connected; 35 or 40-h.p. motors will be required by the former, while 5 or $7\frac{1}{2}$-h.p. motors will be required for the latter. The coal-handling apparatus will consist of a 30-ton coal bin located above the second producer with spouts to the coal hoppers of each producer. A track bin will be located near the producer house and an elevator used for delivering the coal from the track bin to the 30-ton coal bin above the producers.

48 The ash removed from the water seals of the producer will be loaded into a small car which may be hoisted into either a railroad car or ash wagon by means of a block and tackle or an air lift.

49 The building will be of steel frame construction with corrugated iron sides. A charging platform will be built around the producers.

50 For an equipment of this nature, the cost of the producers and auxiliary apparatus erected on the foundations, including the charging platform but not including freight, will be approximately:

Per b.h.p. of the engine	$11.20
Foundation per b.h.p. of the engine	0.48
Coal handling apparatus per b.h.p. of the engine	1.42
Building 50 ft. x 45 ft. per b.h.p. of the engine (not including land)	2.25
Total	$15.35

51 The operating costs[1] may now be taken as follows:

Interest, depreciation, taxes, insurance at 13 per cent per annum per b.h.p-hr. (8760 hr. per yr.), cents	0.02280
Maintenance and repairs, this may be taken at 1½ per cent of the first cost per annum, cents	0.00270

52 The item of supplies is a variable one and depends somewhat upon the behavior of the fuel. If it is a clinkering fuel the cost of bars for poking in itself may amount to quite an item. The total should not amount to over $200 per annum for average conditions, or 0.00185 cents per b.h.p-hr.

53 Labor is also a variable quantity, depending upon the behavior of the fuel, upon the management and upon the amount and kind of coal, ash and tar handling apparatus installed. In the case of the present plant, and with a fairly good fuel, three men per shift of 12 hours should handle the plant with ease.

54 The price for labor varies with the location, but $3 per day for the chief operator and $2 per day for his five assistants is ample. This makes a total of $4745 per year, or $0.0437 b.h.p-hr.

55 The cost of fuel has been taken at $1 per ton and at full load the coal per year will be $\frac{1538 \times 8760}{2000} = 6745$ tons or $6745, or 0.062 cents per b.h.p-hr.

56 We have therefore

	Per B.h.p-hr.
Interest, depreciation, taxes, etc	0.02280 cents
Maintenance and repairs	0.00270
Supplies	0.00185
Labor	0.04370
Fuel	0.06200
Total	0.13305 cents

The total cost of operating the producer equipment at full load is 0.133 cents per engine b.h.p-hr.

57 If it is assumed that the gas generated has an average low calorific value of 136 b.t.u. per cu. ft. of standard gas, $\frac{8465}{136} = 62.2$ cu. ft. will be generated per lb. of coal, and $\frac{10500}{136} = 77.2$ cu. ft. will be required per b.h.p.

[1] Computations have been based on the brake horsepower of the engine and on coal at $1 per ton of 2000 lb. This basis would seem to make the figures most easily applicable to different conditions of load and fuel.

58 From the above 1000 cu. ft. of 136 effective b.t.u. gas will cost 1.72 cents. This figure, as above noted, does not include the cost of land for buildings, freight, nor the cost of scrubber water, which in many cases is obtained at the cost of pumping.

59 From the above figures the cost of power for any given load factor may be obtained and for any given cost of fuel. The power required by the producer auxiliaries remains practically constant, also the fixed charges and labor, unless in the case of the latter the load factor is sufficiently low to dispense with one producer operator per shift. The only variable is therefore the amount of coal used which may be determined from the number of hours of operation and the heat consumption of the engine at different loads, on the assumption that the producer efficiency is constant at all loads from 25 per cent to 1.25 per cent.

FUTURE DEVELOPMENTS

60 Plants of the type described have proved reliable and economical in practically every case. Particularly is this true for plants operating on poor fuels, like the lignites, and plants operating on high priced fuels. The economy obtained depends, however, to a large extent upon the intelligence displayed in the operation and in the design of the plant.

61 The future for these plants is also promising, as more economical results are now recognized as attainable, through the following improvements which reduce the first cost of the plant and also the operating costs:

- *a* Increase in the rate of gasification.
- *b* Decrease in the power required to drive the cleaning apparatus.
- *c* Utilization of waste heat.

Increase in the rate of gasification has been made possible by a careful study of the effect of the distribution of the blast on the operation of the producer.

62 A number of years ago the writer demonstrated on a small anthracite producer in the mechanical engineering laboratory of the University of Illinois, that certain fuels could be gasified at rates as high as 40 lb. per sq. ft. of fuel bed per hour without difficulty. The results of one of these tests were presented to the Society at the Annual Meeting in 1909.[1] Later while operating on lignite in Texas which produced a very fine ash and caused considerable trouble in

[1] Testing Suction Gas Producers with a Koerting Ejector, Trans. vol. 31, p. 831.

the ordinary central blast producer, the prime reason for the satisfactory gasification of one fuel at a very high rate of gasification and the failure in the gasification of another fuel at the same rate, was most clearly and forcibly demonstrated.

63 These two experiences, with a study of the operation of a large number of producers on bituminous, semi-bituminous, lignites, anthracites and semi-anthracites, have led to the complete realization of the three fundamental requirements that must be met in the successful gasification of all fuels as previously set forth, viz.

a Uniform distribution of the green fuel.
b Uniform removal of ash.
c Uniform distribution of the blast.

64 A study of the producers on the market today will reveal the fact that there are few if any that meet all of these comparatively simple requirements. A few have partially done so and have proved successful at low rates of gasification, or at high rates on certain fuels. The Mond producer illustrates the latter, although this fails entirely to meet the first and second requirements, but very nearly meets the third, which is the most important and the end desired.

65 The Taylor producer illustrates the former, for as it was designed it failed to meet requirements *b* and *c*, and, while successful for gasification of 10 lb. and under, was never capable of higher rates on average fuels. A change in accordance with the above requirements demonstrated that a gasification of 15 lb. was accomplished with the same ease as 10 lb. had been accomplished in the past, when operating on a poor grade of anthracite.

66 From this study and investigation it has become apparent that average fuels can be gasified at rates from 50 to 150 per cent greater than the present rating of producers (9 to 10 lb. per sq. ft. of fuel bed per hour), and with no increase in labor. This means a great reduction in the first cost of producer plants and also in the operating costs. Furthermore, the same principles produce the same results in large producers as in small producers, so that it is just as practicable to build a producer of large as of small diameter, while the labor per square foot of fuel bed required in the operation of the producer, the first cost, and operating costs are greatly reduced. A producer 9 ft. in diameter inside the lining, having an area of 63.6 sq. ft., requires less labor to operate than two producers 6 ft. in diameter (area 56.5 sq. ft.), while the quality of the gas is more uniform than that obtained from one of the smaller units. The

same is true of the producer $10\frac{1}{2}$ ft. in diameter, which is easier to operate than two producers 7 ft. in diameter. It is, however, true that the gas from two smaller producers will probably be more uniform in quality than the gas from one large producer. In any case where continuous operation and uniform condition are essential, at least two units should be installed.

67 The writer's experience would indicate that producers up to 15 ft. inside diameter are practical.

68 The power required to drive the cleaning apparatus has previously been referred to (Par. 26).

69 Utilization of the waste heat is an item that has received some attention in the past, but not as much as it warrants. As a rule, the average gas plant is extremely wasteful of heat. About 12 per cent of the heat in the fuel is thrown away in the scrubber water, while about 60 per cent is thrown away in the cooling water to the engine cylinders and in the exhaust. These last two quantities are available for steam raising in the bituminous coal plant. Approximately $2\frac{1}{2}$ lb. of steam can be generated per b.h.p. of the engine. Where there is a fairly uniform load and a demand for this steam, it can be obtained at a comparatively small cost and when credited against the cost of gas at the same rate as the cost of steam by direct firing, reduces the cost of gas from the plant from 12 to 20 per cent. If there is no demand for steam for heating or other purposes it may be used for the generation of power either in engines or turbines.

70 In the case of the 1240-b.h.p. plant just considered, 3100 lb. of steam can be obtained from the engine exhaust and jackets per hour. The exhaust boilers would cost erected, including foundations, about \$2000.

71 For good economy the exhaust boilers should be of the low-pressure self-contained type, generating steam under about 5 or 10 lb. pressure. The heating surface should be approximately twice the amount per b.h.p. as that used in direct-fired boilers. It should not, however, be sufficient to reduce the temperature of the leaving gases below 220 deg. fahr., unless a cast-iron boiler is used.

72 Boilers for this purpose can be made practically automatic in operation and as a rule can be attended by the engine room operators, so that there is essentially no additional operating cost involved.

73 The interest, depreciation, repairs, maintenance, etc., on \$2000 at $14\frac{1}{2}$ per cent per annum is \$290, or 3.31 cents per hour.

The steam if generated in a small direct-fired boiler would cost about 9 cents per 1000 lb. when using coal at $1 per ton. The credit for steam is therefore $3.1 \times 9 - 3.31$ cents per hour, or 0.0198 cents per b.h.p-hr. The cost of operating the producer equipment per b.h.p-hr. would be therefore $0.133 - 0.0198 = 0.1132$ cents. The cost of gas per 1000 cu. ft. would be 1.47 cents.

THE PRESENT STATUS OF THE DIESEL ENGINE IN EUROPE, AND A FEW REMINISCENCES OF THE PIONEER WORK IN AMERICA

By Rudolph Diesel, Munich, Germany

Honorary Member of the Society

There have been so many publications recently, especially during the past year, on the construction of the Diesel engine and its various types, that it is hardly possible to give any fresh information on this subject. I propose, therefore, to admit as generally known the working principle and construction of my engine and to discuss only questions of general importance.

Since its first appearance in 1897, many Diesel engines have been built in all industrial countries and it has proved reliable when properly constructed. The thermal or indicated efficiency now reaches 48 per cent in this engine, and the effective or brake efficiency in some cases 35 per cent of the heat value of the fuel.

Fig. 1 shows the heat utilization for 1 b.h.p-hr. in the different kinds of prime movers now known, and Fig. 2 shows a comparison of working and test results of steam plants, gas plants and Diesel engine plants.

The Diesel engine converts the heat of the natural fuel into work in the cylinder itself without any previous transforming process, and utilizes it as far as the present standard of science permits; it is, therefore, the simplest and at the same time the most economical prime mover. The working process for both the four-stroke cycle and two-stroke cycle engines is shown in Fig. 3, and indicator diagrams in Fig. 4.

The success of the Diesel engine is not due to constructional improvements or alterations of older types of engines, but to its

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Address given at a meeting of The American Society of Mechanical Engineers, New York, April 30, under the auspices of the Gas Power Section of the Society, at which honorary membership was conferred on Dr. Diesel.

new principle of the internal working process. A further reason is that the Diesel engine has broken the monopoly of coal, and has solved the problem of using liquid fuel for power production in its simplest and most general form. It has become for all liquid fuels what the steam engine and gas engine are for coal, but in a much simpler and more economical way. The truth of this statement was strikingly proved at the Turin exhibition of last year, where a steam

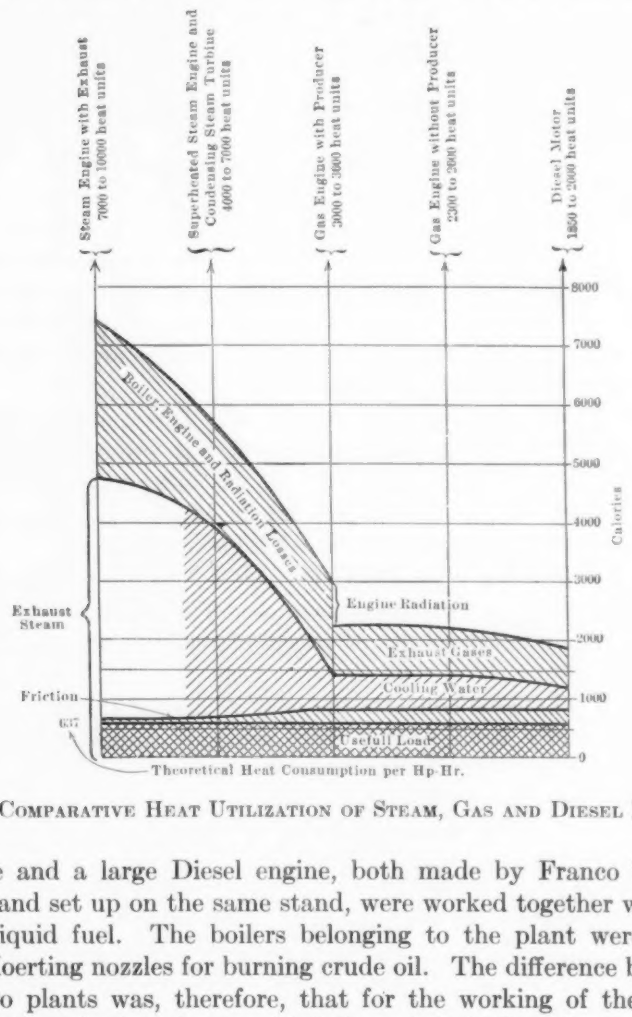


FIG. 1 COMPARATIVE HEAT UTILIZATION OF STEAM, GAS AND DIESEL ENGINES

turbine and a large Diesel engine, both made by Franco Tosi of Milan and set up on the same stand, were worked together with the same liquid fuel. The boilers belonging to the plant were fitted with Koerting nozzles for burning crude oil. The difference between the two plants was, therefore, that for the working of the steam engine there had to be provided the whole boiler plant with its chimney, fuel supply apparatus, feed pumps and purification plant

for feedwater, and steam piping; and the condensation plant with auxiliaries and an enormous water consumption. The steam plant showed a final result of two and one-half or more times the fuel per horsepower per hour required by the Diesel engine standing beside it. The latter, being an entirely independent engine without any auxiliary plant, took up its crude fuel automatically and consumed it direct in its cylinders without any residue or smoke.

UTILIZATION OF NATURAL PRODUCTS

Thus the Diesel engine can double the resources of mankind as regards power production, and has made new and hitherto unutilized products of nature available for motor power. The Diesel engine has thereby exercised a far-reaching influence on the liquid fuel industry, which is at the present time improving more rapidly than was previously conceived possible. This is not the place to discuss this matter in detail, but I wish to mention that, owing to the interest which petroleum producers have taken in this important question, new petroleum sources are continually being developed and new oil districts discovered. Moreover, it has been proved by recent geological researches that there is probably on the globe not only as much but even more liquid fuel than coal, and also that it is more conveniently distributed as regards its geographical position. These facts, which are indisputable, have gradually silenced those who objected to too great a development of the Diesel engine for fear of insufficient stores of liquid fuel.

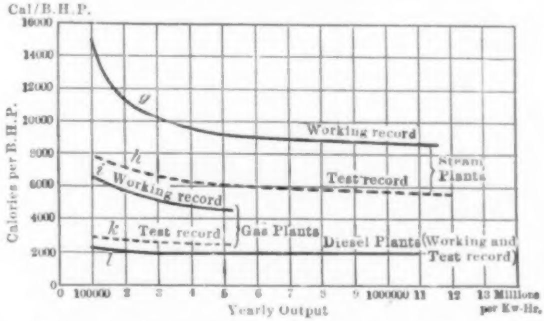


FIG. 2 COMPARISON OF WORKING AND TEST RESULTS FOR STEAM, GAS AND DIESEL ENGINES

That the auxiliary industries of petroleum production are also considerably influenced is shown by the great increase which the

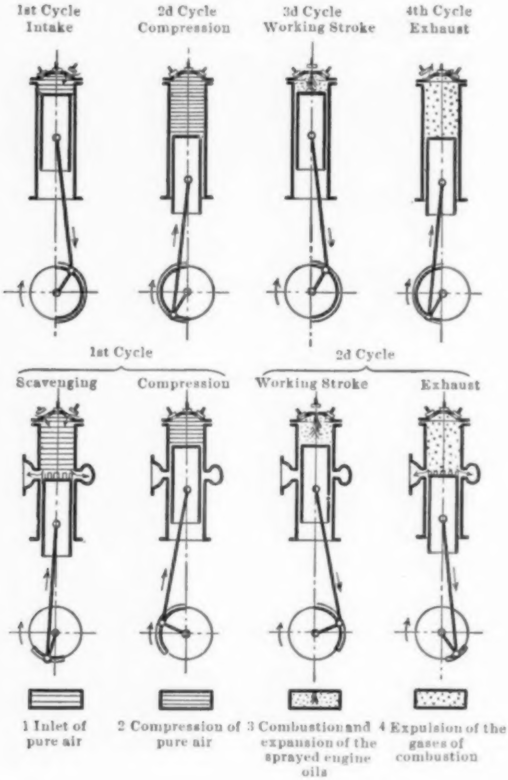


Fig. 3 Working Process of Four-Cycle and Two-Cycle Engines

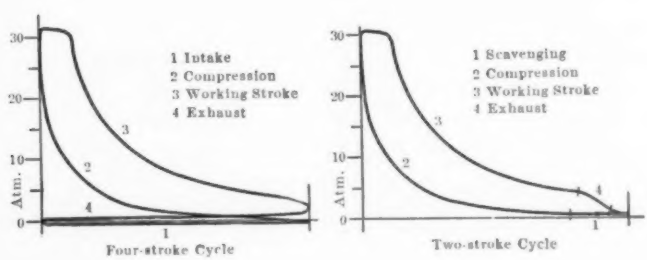


Fig. 4 Indicator Diagrams of Four-Cycle and Two-Cycle Engines

transport industry for liquid fuel has experienced in recent times, especially in the great development of tank vessels, which are, or will be, mostly driven by Diesel engines.

But with all this, the influence of the Diesel engine on the world's industries is not exhausted. As early as the year 1899, I utilized in my experimental engine the by-products of coal distillation and coke plants, such as tar and creosote oils, with the same satisfactory results as with natural liquid fuels, but at that time the quality of these oils was generally too inferior for their use in the Diesel engine, and it was, moreover, subject to continual variations. It is only in

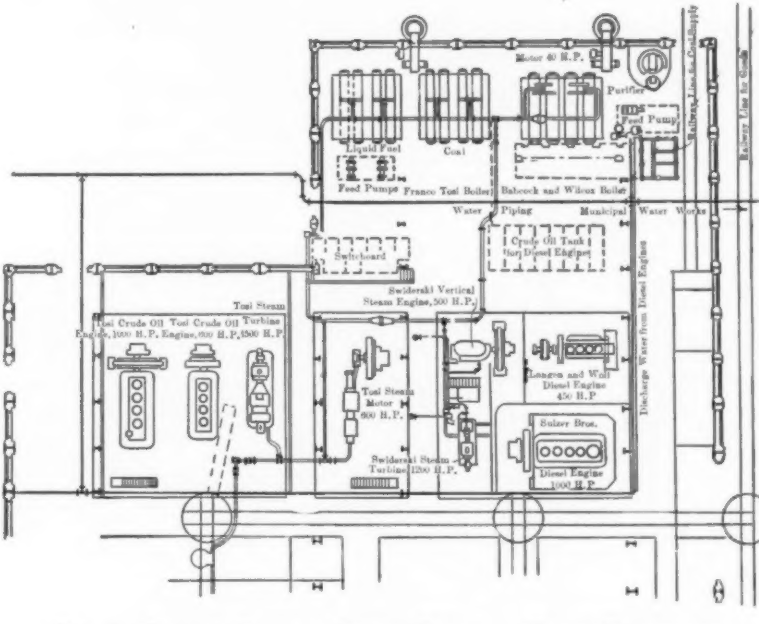


Fig. 5 Ground Plan of Power Plant at Turin Exhibition

recent years that the chemical industries interested in the matter have, by improved methods of fractioning and refining, combined with more careful selection of the material, succeeded in supplying fuel of a constant and regular quality without the drawbacks of the crude tar oils used previously. These products, the tar and tar oils, are thus definitely brought into the sphere of activity of the Diesel engine.

This fact is not so important in the United States because of its

richness in natural oil, but it is for European countries, especially those countries not having an oil production of their own. It may be of interest to state, for instance, that the tar production of Germany is sufficient for more than five millions of horsepower-hours per year, which means about one and three-quarter millions of horsepower running 300 days for ten hours each all the year. In case of war and the cutting off of the supply of foreign fuel, this quantity would be sufficient to run the whole fleet, war and mercantile, and to provide in the meantime the power for the inland industries so far as necessary.

In this connection it is a pleasure to say that the first industrial utilization of the by-products of gas manufacture by Diesel engines was made in this country by Col. E. D. Meier, Past-President of

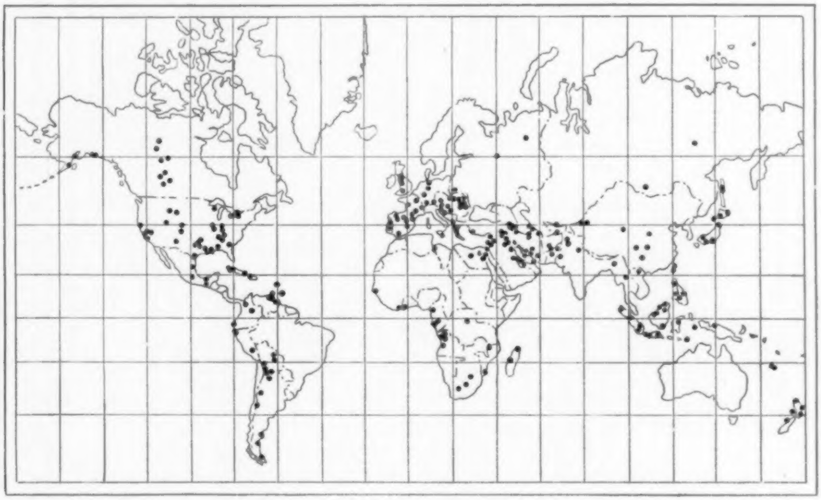


Fig. 6 The World's Oil Fields

The American Society of Mechanical Engineers, who, in the year 1904, was the first to burn water gas tar of the gas works in Philadelphia in regular work for Diesel engines.

It will be seen from this that the influence of the Diesel engine on two other industries is increasing the manufacture of gas and coke, the by-products of which have become so important for power production that an enormous business is at present connected with them. It is especially noteworthy that every modern gas or coke works can be arranged to generate electric power by using its tar in Diesel engines. One fact which stands out clearly in this connection

is that coal, which seemed to be most threatened by the liquid fuels, will on the contrary gain a new and wider ground of application through the Diesel engine. As tar and tar oils are from three to five times more satisfactorily utilized in the Diesel engine than coal in the steam engine, a much better and more economical consumption of coal is obtained if, instead of being burned under boilers on grates in a wasteful way, it is first transformed into coke and tar by distillation. Coke is used in metallurgical and other general

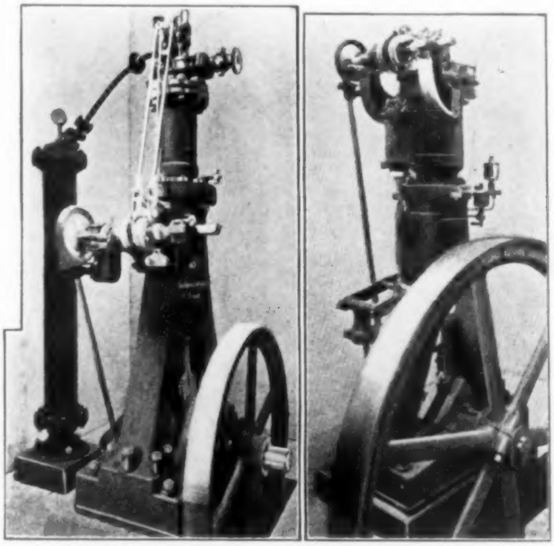


Fig. 7 First Two Diesel Engines built

heating purposes and from a part of the tar the valuable by-products are first extracted and undergo further processes in the chemical industry, while the tar oils and combustible by-products and a great part of the tar itself are burned in the Diesel engine under very favorable conditions.

It is evident that these circumstances are of differing importance in different countries, some of which are exclusively coal countries, others oil countries, and others again, like the United States, mixed coal and oil countries. It is difficult to predict what development will take place in a given country, but it is certain that the possibility of burning the by-product of gas works and coke ovens in the Diesel engine has resulted in Europe in making the different countries inde-

pendent as regards their supply of liquid fuel and has prevented increase in price of natural liquid fuel and the establishment of trusts or monopoly companies. This condition has been reached, not by laws or artificial means, but by the invincible force of scientific investigation and industrial progress before which the mightiest must bow.

The following statement may be made: The proper development of the utilization of fuel which has already been started and is now making rapid progress consists, on the one hand, of the use of liquid

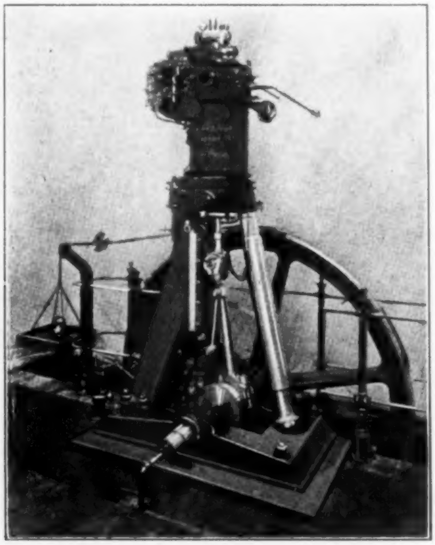


FIG. 8 THIRD DIESEL ENGINE BUILT. VIEW SHOWS TESTING BRAKE

fuel in Diesel engines, and, on the other, of gas fuel, also in the form of gasified coke, in the gas engines; solid fuel as little as possible for steam power generation, but as much as possible in the refined form of coke for all other heating and metallurgical purposes.

It is not generally known that it is possible also to burn vegetable and animal oils in the Diesel engine without difficulty. The first trials were made at the Paris Exhibition in 1900 with earth-nut oil, and I have since then repeated them with castor oil and palm oil, and also with animal oils such as brain oil. The use of vegetable oils may seem insignificant now, but may have in course of time an importance equal to that of some natural mineral oils and the tar

products at the present time. One can not tell what part these oils will play in the colonies of the future. In any case, it is certain that motor power can still be produced from the heat of the sun, which is always available for agricultural purposes, even when all our natural stores of solid and liquid fuels are exhausted.

HISTORY OF THE DIESEL ENGINE

I will now present an historical summary of the Diesel engine and will speak first of the four-stroke cycle engine. The first vertical stationary Diesel engine constructed in 1893 had the piston fitted

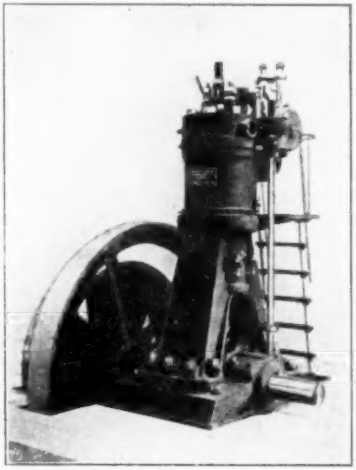


FIG. 9 DIESEL ENGINE BUILT IN 1901

with a piston rod and external crosshead, the cylinder having no water jacket. The camshaft was arranged very low and the valves were actuated by means of long rods. The starting storage chamber consisted of a wrought-iron pipe with riveted flanges and there was no air supply pump, the fuel being injected directly. I never succeeded in running this engine, not even one revolution. At the first injection of fuel—the engine being driven by outside power—there occurred a terrific explosion and the indicator went to pieces, nearly killing me. But I knew then just what I wanted to know: Pure air could be compressed to so high a point that the fuel injected into it would ignite and burn.

I then built my second engine. It had a base similar to that shown before, but a water-jacketed cylinder and the camshaft was placed

higher up. The most important difference was in the air supply pump for the injection of fuel, the necessity for which was only recognized after several years' experimenting and without which a smokeless combustion could not be effected.

The second engine also would not run and was always a source of danger. But it gave the first indicator cards of the whole cycle in the few revolutions I could get out of it. These first two engines taken together proved the practical possibility of carrying out the combustion process which I had developed theoretically years ago and which had been regarded impossible by the technical world. I myself would never have had the patience and the courage to continue the work after the disappointments of the first two years of experimenting, had I not been supported by an unalterable belief in the correctness of my mathematical deductions.

Fig. 8 shows the first reliable and complete Diesel engine finished in 1897 at Augsburg after about four years' laborious experimenting. It was a vertical engine of 18 h.p. having the piston connected to an external crosshead and worked on the four-stroke cycle. The illustration shows the engine with the testing brake attached, and with the other testing apparatus in the exact position in which it was used by the numerous commissions of engineers and experts who came from different countries to examine it. One of these experts was Col. E. D. Meier, who passed a few weeks in the engine room at Augsburg, testing and trying the little engine over and over again, and cross-examining the operating engineer, and thus forming his opinion about its significance. He was one of the first engineers to recognize its possibilities in the economical utilization of oil fuels through the practical realization of the Carnot cycle.

Mr. Adolphus Busch of St. Louis when on the point of sailing for home summoned Col. Meier to Paris, and after reading his report and discussing it from all points agreed in its conclusions and arranged a meeting with me at Cologne, at which we formulated and signed a contract giving Mr. Busch the control of my patents in the United States. Both gentlemen have since been the faithful pioneers of the engine in this country.

In the following year, 1898, a single-cylinder engine of 20 to 25 h.p. was built at the Augsburg works. It had all the characteristic details of the experimental engine just mentioned and was the first commercial machine. This type has remained up to the present the exclusive and almost stereotyped pattern for all stationary slow-speed Diesel engines built in the various countries.

The only alteration made in the year 1901 was the abandonment of the external crosshead and adoption of the trunk piston shown in Fig. 9. Vertical four-stroke cycle engines of from 10 to 250 h.p. per

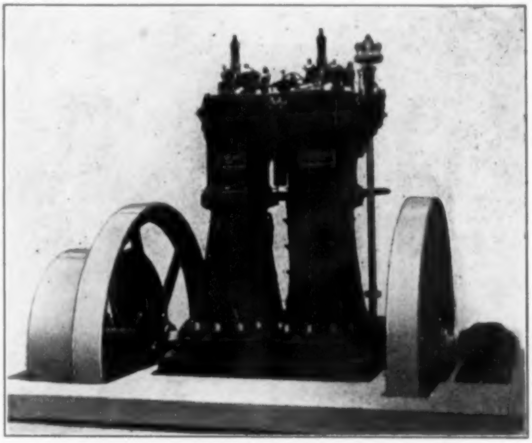


Fig. 10 250-H.P. Two-Cylinder Diesel Engine built in 1902

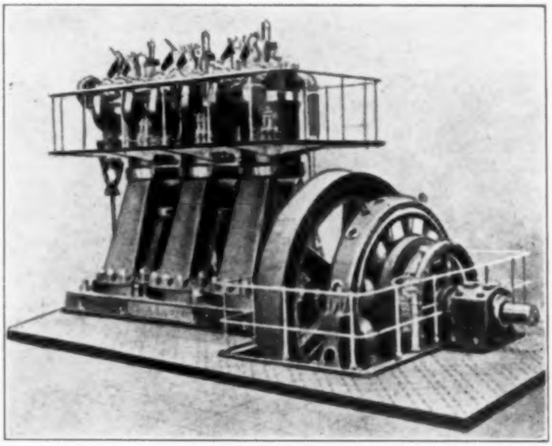


Fig. 11 500-H.P. Three-Cylinder Diesel Engine built by Carels, exhibited at Liege in 1905

cylinder were constructed after this pattern, and units up to 1000 h.p. were obtained by combining several cylinders. These engines ran at comparatively low speeds, from 160 to 200 revolutions, ac-

cording to their size, and were of very heavy construction. This type of engine was used exclusively as a stationary plant for various industrial purposes. Fig. 10 shows a two-cylinder engine of this type of 250 or 125 h.p. per cylinder built in 1902.

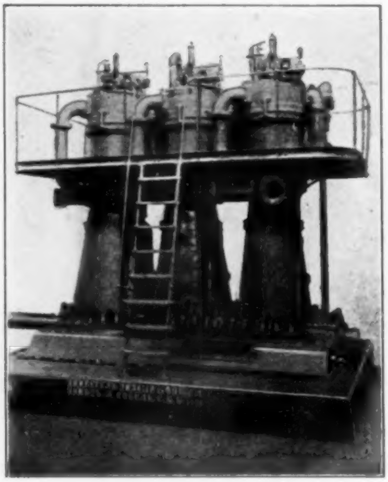


FIG. 12 400-H.P. THREE-CYLINDER DIESEL ENGINE BUILT IN RUSSIA

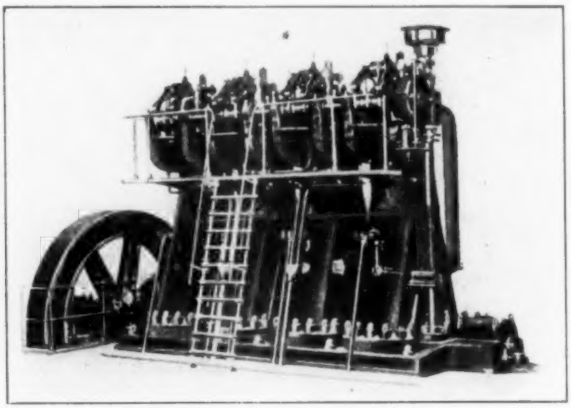


FIG. 13 600-H.P. FOUR-CYLINDER DIESEL ENGINE BUILT BY TOSI IN 1911 AND EXHIBITED AT MILAN

Fig. 11 shows the well-known 500-h.p. three-cylinder engine exhibited by Carels at Liege in 1905. Fig. 12 shows a Russian 400-

h.p. three-cylinder engine, and Fig. 13 quite a new Italian four-cylinder engine of 600 h.p. built by Tosi in 1911 and exhibited in 1911 at Milan.

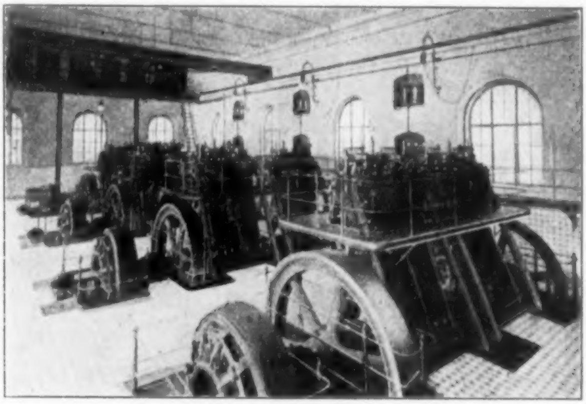


FIG. 14 1600-H.P. DIESEL ENGINE PLANT OF THE RUSSIAN TOWN KIEV FOR THE ELECTRICAL CITY RAILWAY

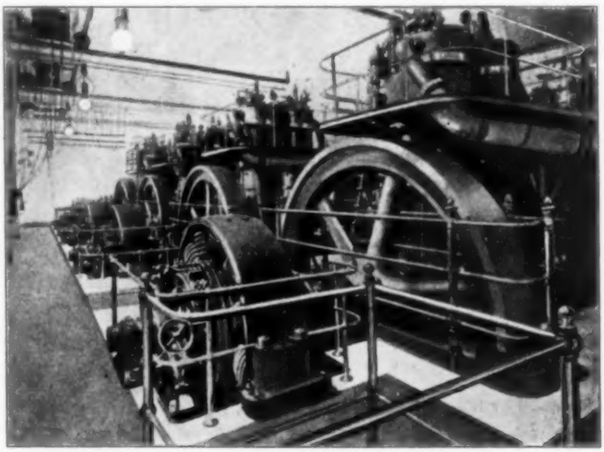


FIG. 15 800-H.P. DIESEL ENGINE PLANT IN THE BASEMENT OF THE TIETZ DEPARTMENT STORE, MUNICH

MODERN EUROPEAN INSTALLATIONS

Figs. 14 and 15 show some large European installations. The first is a 1600-h.p. plant built for the electrical railway of the Russian

town of Kiev, and Fig. 15 an 800-h.p. plant in the basement of the Tietz department store at Munich. These two engine houses are typical of our European plants in the center of our big cities, electric stations and power plants in big stores, hotels, restaurants and the like. For it has been fully recognized that the Diesel engine is the predestined engine for big centers owing to the absence of steam boilers, smoke, and coal manipulation, the small space occupied, cleanliness, and the complete freedom from danger. These engines are the only ones that can be installed in cities in any country without some special concession or permit.

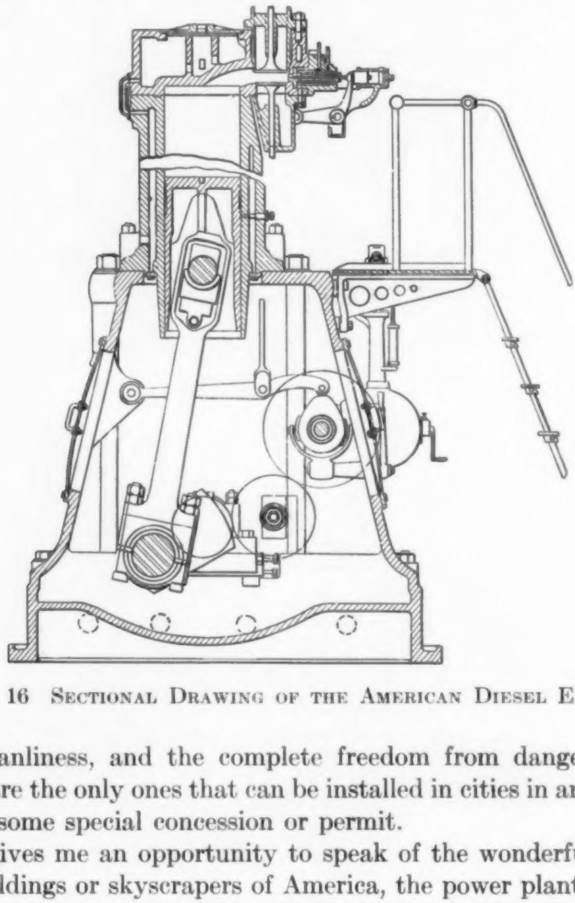


Fig. 16 Sectional Drawing of the American Diesel Engine

This gives me an opportunity to speak of the wonderfully developed buildings or skyscrapers of America, the power plant of which, as far as I know, is generally a steam plant. I think that it would be a great improvement to serve these buildings mechanically by Diesel engines, the waste or exhaust heat of which would be sufficient to generate all the hot water necessary for use in the building. The steam heating alone would have to be done by boilers, which,

of course, would be fired by the same fuel as the Diesel engine and would be entirely stopped for the summer months of the year. Such installations would be not only simpler but also more economical in

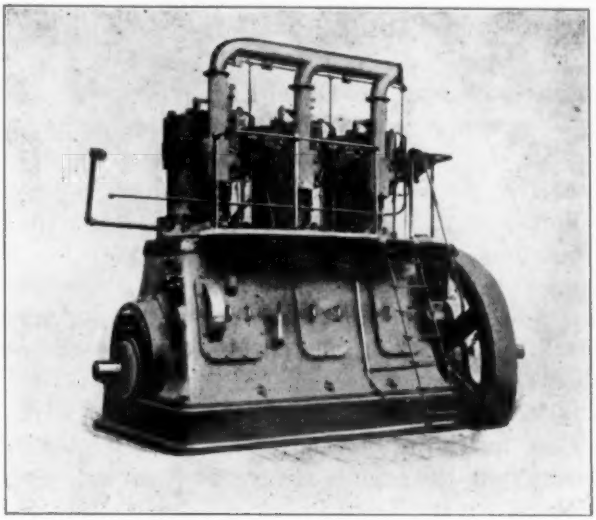


FIG. 17 OUTWARD APPEARANCE OF AMERICAN DIESEL ENGINE

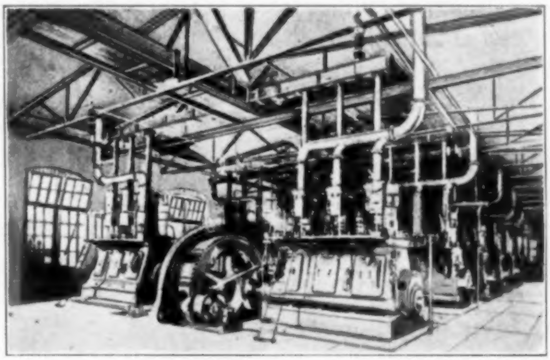


FIG. 18 VIEW OF DIESEL ENGINE PLANT, PRAIRIE PEBBLE PHOSPHATE COMPANY, MULBERRY, FLA., CONSISTING OF EIGHT DOUBLE UNITS OF 450 H.P. EACH

operating cost and would do away with the smoke problem in the large centers.

AMERICAN INSTALLATIONS

I have given several examples of this type of engine to show that those which have been built in various factories and countries are almost an exact copy of the old experimental engine which is today in the German Museum at Munich. Only in America has the design been simplified by the American Diesel Engine Company, succeeded by the Busch-Sulzer Brothers Diesel Engine Company, of St. Louis. In America these engines were built, from the beginning, without crossheads, an idea which, as already mentioned, was followed in the year 1901 by the European works after the American engines with trunk pistons had proved successful. They were also built from the beginning with a closed base frame, and this construction, as will be seen later, has also been adopted recently in the European high-speed engines. The American engines had no valves in the cylinder head, but they were placed in a chamber cast at the side of the cylinder head which necessitated the fuel needle being placed horizontally between the suction and the exhaust valves. Finally, the Americans, instead of driving the air pump for the injection of the fuel direct from the engine, always set it up independently and drove it either by a small extra engine, a transmission shaft, or an electric motor, in the manner in which air pumps are now set up in many Diesel engine plants on board foreign ships.

The accompanying illustrations, Figs. 18, 19 and 20, show some of the larger Diesel engine plants in this country. Fig. 18 is the plant of the Prairie Pebble Phosphate Company at Mulberry, Fla., so far the largest Diesel plant in America. This plant has 16 Diesel engines in 8 double units of 450 h.p. each and only 5 air compressors. Fig. 19 shows two 225-h.p. engines at the plant of the Pittsfield Electric Company, Pittsfield, Mass., and Fig. 20, three 225-h.p. engines at the United Gas Improvement Company's Works, Philadelphia, Pa.

The total aggregate of Diesel engines in the United States is now about 150,000 h.p. in about 300 plants.

As the central electric stations took up the Diesel engine very early, the necessity for quicker running engines arose. This need and the improvement in methods of construction and utilization of materials caused the gradual introduction of the new quicker running four-stroke cycle engines, with speeds of from 300 up to 600 revolutions. These, however, were still exclusively vertical. The main difference in construction as compared with the first type, was that the bearings of the crankshaft were connected with the cylinders by

means of light steel columns instead of by heavy cast-iron A-shaped frames, so that the cast-iron pedestal of the machine became a light crank case relieved from great strain; in addition, the thickness of all the castings was diminished. By this means the weight of the

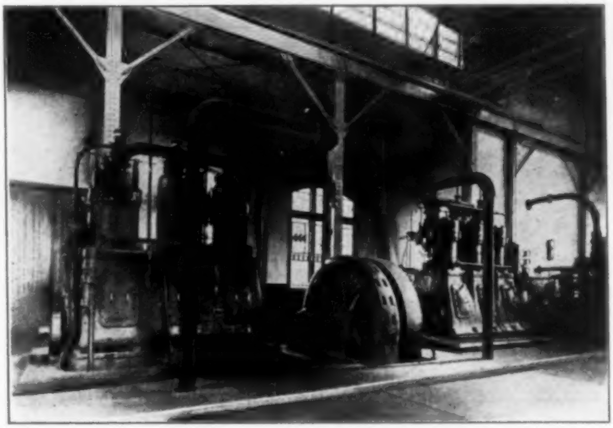


FIG. 19 VIEW OF DIESEL ENGINE PLANT, PITTSFIELD ELECTRIC COMPANY, PITTSFIELD, MASS.

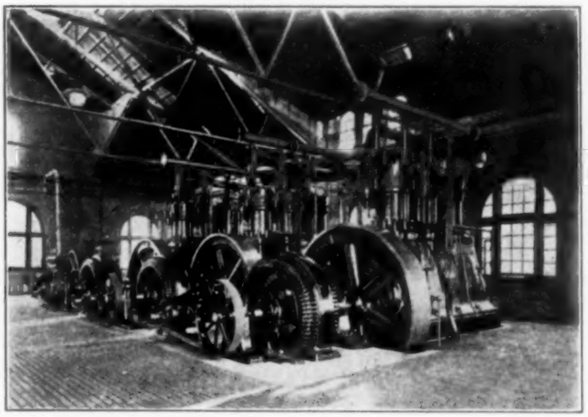


FIG. 20 VIEW OF DIESEL ENGINE PLANT, UNITED GAS IMPROVEMENT COMPANY, PHILADELPHIA, PA.

engines was reduced to about one-fourth or one-fifth of the weight of the old types, or to about 50 kg. (110 lb.) per horsepower. Four-stroke engines of this kind are now built up to about 700 h.p. and are

especially suited to drive dynamos, blowers, and centrifugal pumps, and also as auxiliary engines on board large vessels, etc.

Fig. 21 shows a four-stroke cycle high-speed engine of this type made by Messrs. Sulzer Brothers in the year 1909. Fig. 22 shows a

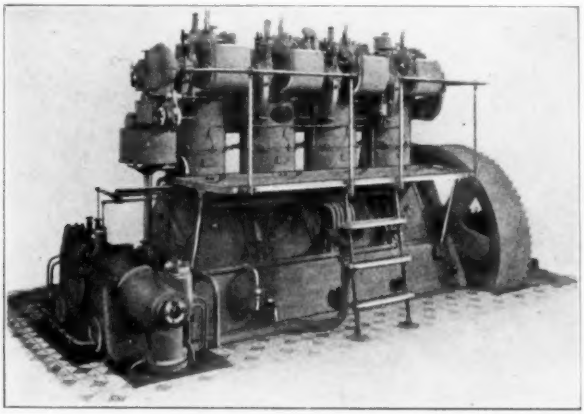


FIG. 21 HIGH-SPEED FOUR-STROKE DIESEL ENGINE BUILT BY SULZER BROTHERS IN 1909

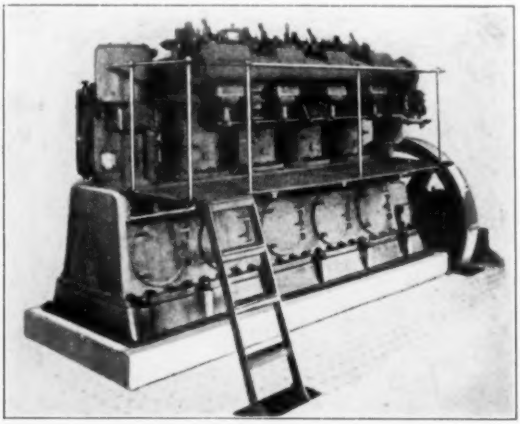


FIG. 22 HIGH-SPEED FOUR-STROKE 350-H.P. DIESEL ENGINE BUILT BY SULZER BROTHERS IN 1911

four-stroke cycle high-speed engine of 350 h.p. made by Sulzer Brothers in 1911. This latter may be regarded as the final and permanent type of the vertical four-stroke cycle engine for stationary purposes, both for high and low speeds.

When in the last decade, through rapid development of the French submarines, an urgent need for a reliable submarine engine was felt, these four-stroke cycle engines were further reduced in weight by

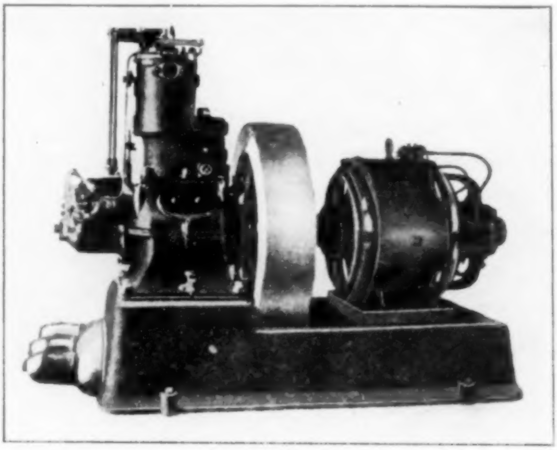


FIG. 23 5-H.P. ONE-CYLINDER DIESEL ENGINE, 600 B.H.P., BUILT IN 1909

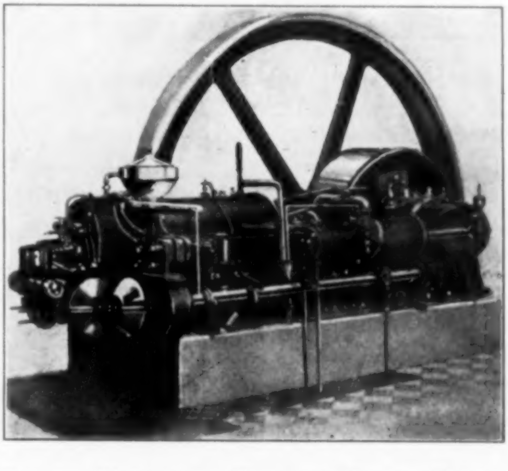


FIG. 24 HORIZONTAL KOERTING DIESEL ENGINE

using steel and brass castings, with still thinner walls, and they have also been fitted recently with reversing gears. I will return to this point later when discussing marine engines.

SMALL ENGINES

This summary of the development of the vertical four-stroke cycle engine would not be complete without a reference to the small engine which has recently been built. Fig. 23 shows a complete 5-h.p. one-cylinder plant, designed in 1909, for 600 r.p.m., driving a dynamo. For this construction, many hints have been taken from automobile engine designs.

HORIZONTAL STATIONARY ENGINES

After vertical engines had been used solely for about twelve years, horizontal four-stroke cycle engines were built. The first horizontal

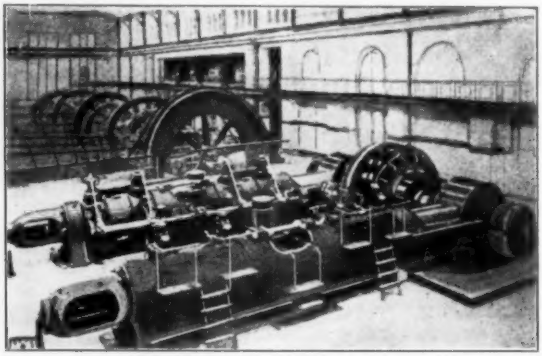


Fig. 25 Double-Acting Four-Stroke Twin Engine of 1800 to 2000 H.P., or 400 to 500 H.P. per Cylinder, 250 R.P.M., built by Maschinenfabrik Augsburg Nuremberg

engines were practically vertical engines laid on their sides without any independent structural innovations, as can be seen from Fig. 24, a horizontal Koerting engine in which all the valves are fitted in the cylinder cover in exactly the same way as in the old vertical engine. Gradually the designers freed themselves from the tradition of the vertical engine, and some details were so altered as to be more suitable for the horizontal position, and a type of engine was thus obtained which, in outward appearance, is strongly reminiscent of the horizontal gas engine. The Maschinenfabrik Augsburg Nuremberg built such horizontal Diesel engines for very high horsepower as double-acting four-stroke cycle engines with two or four cylinders arranged tandem. The largest engine of this kind is shown in Fig. 25; it is a double-acting four-stroke cycle tandem twin engine of 1600 to 2000 h.p., or 400 to 500 h.p. per cylinder, with a speed of 250 r.p.m.; this engine works entirely on water gas tar.

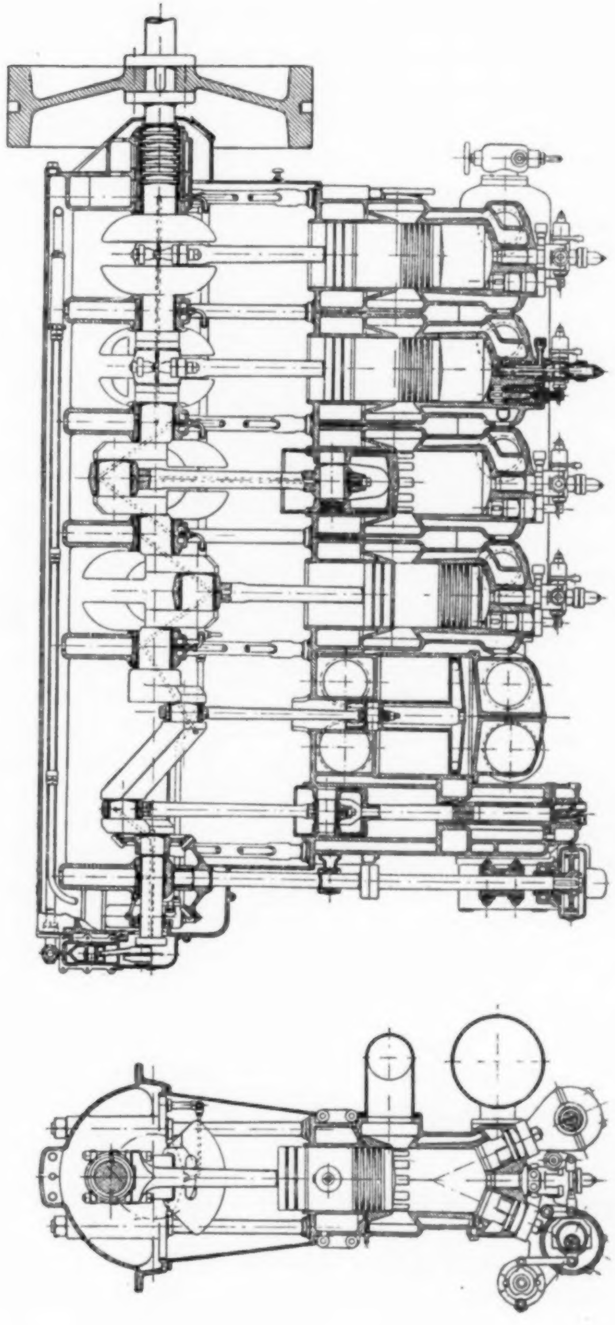


FIG. 26 SECTIONAL DRAWING OF SULZER BROTHERS' TWO-CYCLE ENGINE

TWO-STROKE CYCLE ENGINES

As I have often stated, the Diesel principle is essentially suitable in a two-stroke cycle engine, because the scavenging is not done with a fuel air mixture but with pure air, so that not only untimely ignitions are avoided, but fuel losses as well, and the scavenging can be done effectively and with almost any quantity of air desired. The two-stroke type is now almost on an equal footing with the old four-stroke cycle engine. This has been effected by working entirely on the original Diesel principle. I say "almost equal" because the four-stroke cycle engine still has better combustion and more economical fuel consumption, and is, above all, simpler in its method of working. It thus remains the standard perfect engine and still predominates for medium sized stationary plants up to 500 or 600 h.p. (no exact limit can be given), wherever the highest perfection and the greatest economy are desired. On the other hand, the two-stroke cycle engine with its smaller cylinders has now come into favor for stationary plants of higher horsepower, and, as a marine engine, seems to be the standard type. Two very different fundamental types of two-stroke cycle engines have so far been competing. The first is the engine made by Messrs. Sulzer Brothers, Winterthur, with separate scavenging pump, Fig. 26. The second, the Maschinenfabrik Augsburg Nuremberg engine, was brought out much later, and has a scavenging pump with an annular or stop piston placed underneath each combustion cylinder. Both engines are single-acting. Their relative merits can be settled only by experience.

A three-cylinder 750-h.p. Sulzer-Diesel two-stroke cycle engine and a still larger Sulzer-Diesel four-cylinder two-stroke cycle engine of the same system, of 2000 to 2400 h.p., are illustrated in Figs. 28 and 29. For the latter size two scavenging pumps are necessary.

MARINE ENGINES

The first marine Diesel engine of 20 h.p. was constructed in France in 1902 to 1903 for use on a canal boat, by the French engineers Adrien Bochet and Frederic Dyckhoff, in conjunction with myself. This engine had two pistons working in opposite directions in one cylinder, and worked on a four-stroke cycle. Others were also built in various sizes up to several hundred horse-power for some French submarines by Sautter, Harlé & Company, Paris.

This type of engine is of no practical interest today, but it has the historical interest at least of being the first Diesel engine used on a boat. Since the date named, the evolution of the Diesel marine

engine has steadily continued, chiefly because of the demand of the French submarines and Russian river boats. I have already mentioned that, later on, the high-speed four-stroke cycle engines, built for electric power stations, were made even lighter than before, and used for these same marine purposes. These engines were not orig-

FIG. 28 750-H.P. THREE-CYLINDER SULZER BROTHERS' TWO-CYCLE ENGINE (STATIONARY)

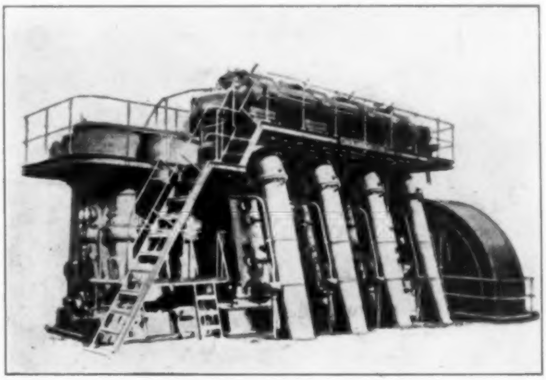


FIG. 29 2400-H.P. FOUR-CYLINDER SULZER BROTHERS' TWO-CYCLE ENGINE

inally reversible; on the contrary, they were used to generate electricity by means of which the propellers were driven indirectly for manoeuvering.

The first reversing marine two-stroke cycle Diesel engine, shown in Fig. 30, was built in 1905 by Messrs. Sulzer Brothers at Winter-

thur. At that time engineers were not quite clear as to the importance and value of the two-stroke cycle principle, and many firms went on trying for years to make the four-stroke cycle engine reversible. The first engine of this kind was built in the year 1908 by Messrs. Nobel Brothers at St. Petersburg, and was fitted to a Russian sub-

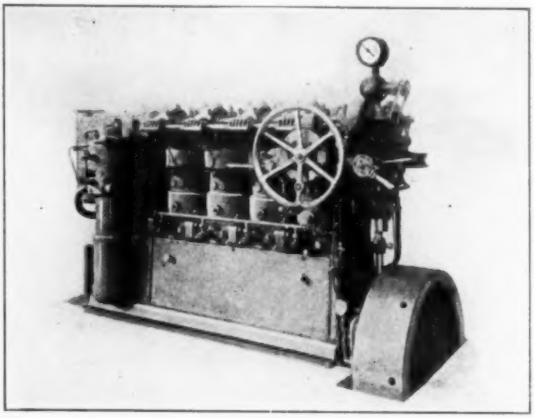


Fig. 30 First Reversing Two-Cycle Diesel Engine, built by Sulzer Brothers in 1905

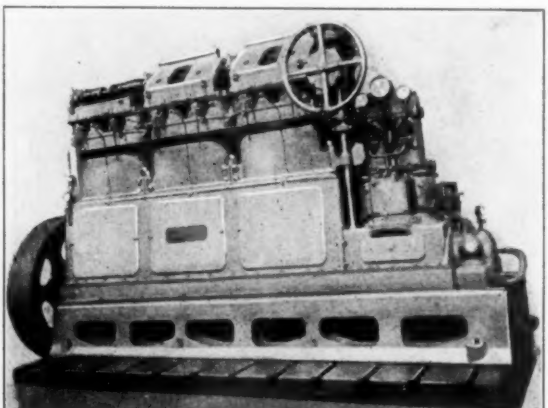


Fig. 31 120-H.P. Three-Cylinder Reversible Marine Engine

marine. Fig. 31 shows this 120-h.p. three-cylinder engine. It is apparent even from the outside view what great mechanical com-

plications were at first caused by making the four-stroke engine reversible.

In many factories reversible four-stroke cycle marine engines are still built; but on the whole, engineers are inclined to abandon the four-stroke cycle engine entirely for navigation purposes, and to replace it by the two-stroke cycle engine.

The small four-cylinder engine of 30 h.p. and 600 r.p.m., illus-

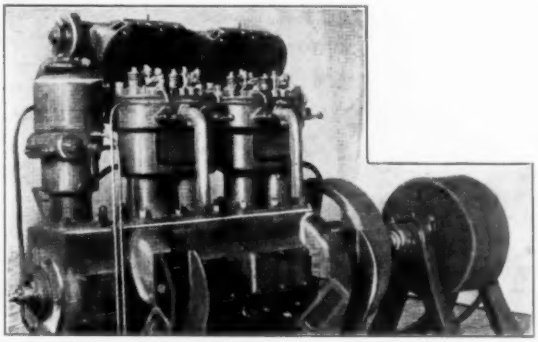


Fig. 32 30-H.P. Four-Cylinder 600-R.P.M. Four-Stroke Diesel Engine, built in 1909 experimentally as an Automobile Engine

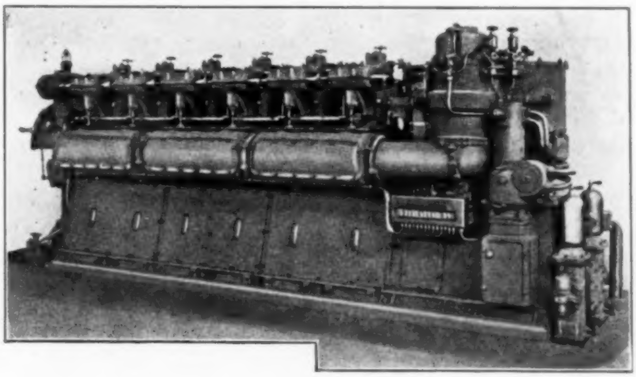
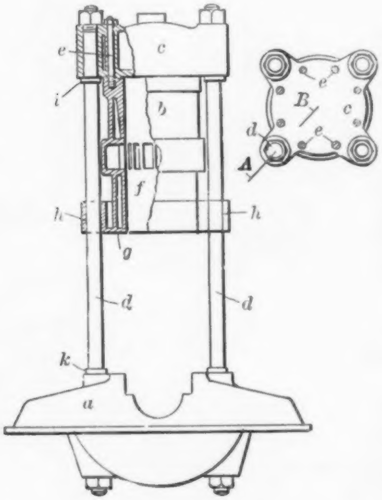


Fig. 33 Latest Two-Stroke Reversible Marine Engine built by Sulzer Brothers

trated in Fig. 32, is also a reversible four-stroke cycle engine. It was built for experimental purposes in 1909 as an automobile engine for heavy loads, but it can also easily work as a marine engine. The camshaft is mounted on the cylinder cover, and the illustration

shows the engine with the cover lifted. The view is of historical value in so far as it illustrates the first attempt to construct the Diesel engine as an automobile engine for traction wagons, and no doubt in future years these experiments will lead to satisfactory results.

Fig. 33 illustrates the latest two-stroke marine engine of Messrs. Sulzer Brothers which may be considered today as the standard type of a marine engine for smaller and medium sized powers.



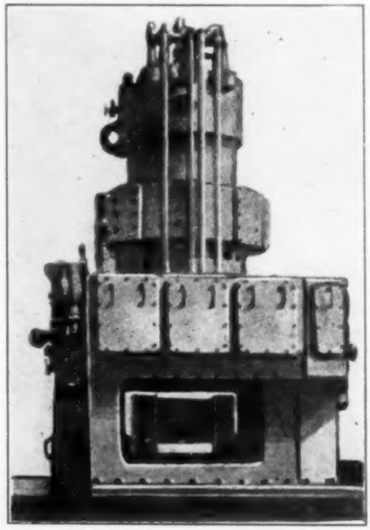


Fig. 34 Sectional Drawing showing Cylinder of 2000 H.P. (Design by Sulzer Brothers)

Fig. 35 Experimental Cylinder Unit of 1000 to 1200 H.P., built by Carels

For larger sizes of ship engines no standard type can be designated as yet. Each ship and each engine must be treated individually. Although several of the Diesel liners are still equipped with four-stroke engines, it is probable that the large ship engines will develop as a two-stroke type with crossheads and with exactly the number of revolutions required by the propeller. There is a tendency to make these engines to resemble steam engines as nearly as possible, even in those points where it would not be necessary, because the marine people adopt new types of apparatus more readily when they resemble apparatus that they are accustomed to.

It is generally known that very important experimental work

is being done in different places for the purpose of developing high power marine engines with cylinder units reaching 1000 to 2000 h.p. and more. Some manufacturers solve this problem with double-acting cylinders and others with single acting; but all on the two-stroke cycle. The Maschinenfabrik Augsburg Nuremberg is experimenting on a 6000-h.p. two-stroke double-acting engine with three cylinders of 2000 h.p. each. Messrs. Sulzer Brothers are just erecting a single cylinder of 2000 h.p., single-acting, Fig. 34, which permits an entirely free expansion of the cylinder under the action of the varying temperatures. Krupp's Germania yards have a 2000-h.p. double-acting cylinder on the testing stand. Vickers Sons and Maxim are experimenting on a large scale with the double-acting two-stroke cycle type. These large cylinder units are kept secret as long as the experimental work is going on, so that views of them can not be shown, but Fig. 35 shows a cylinder unit of 1000 to 1200 h.p., built by Messrs. Carels, which is yet in the experimental stage like all others of these large cylinders.

If, as seems probable, these tests give satisfactory results, the era of very large Diesel engines has begun. From motives of prudence, the various navies which are now fitting some warships with Diesel engines, started with one Diesel only out of the two or three engines on board; the Diesel works alone when the ship is cruising, but for high speed, steam is used as an auxiliary. It is evident that large warships will not be fitted solely with Diesel engines until practical tests on the high seas have proved to be completely successful.

DIESEL SHIPS

I believe it will be of interest to give a complete list of Diesel propelled ships, but as this would be too long, I will simply give a summary of Diesel engine vessels completed or in course of construction. The total aggregate of these vessels is 365, and an analysis shows the following approximate distribution:

Oil tank vessels	30
Tugs	40
Motor sailing vessels	10
Merchant vessels, freight, passenger and combined	50–60
Fishing boats	15
Submarines (among them 17 U. S. Navy submarines)	140
Smaller warships, small cruisers, gunboats, mine-laying boats, and the like	40
Small marine craft	20
Miscellaneous	20

A brief historical review of Diesel ships with results of trials and journeys, as far as a record of them has been obtainable, follows:

The *Venoge* is one of the very first small cargo boats plying on Lake Geneva, with non-reversing engines driving the propeller elec-

FIG. 36 PASSENGER DIESEL SHIP *Uto*

FIG. 37 GERMAN TUG *Fortschritt*

trically. The captain manoeuvers the ship from his bridge only by electrical contacts, the motor running below him without any engineman. This boat exhibits the characteristic features of the Diesel ship, namely, the motor is as far back as possible, the absence of a funnel, the deck quite clear and the whole body free for cargo.

Fig. 36 is a view of the *Uto*, a passenger vessel on Lake Zurich of 200 tons displacement, 250 to 260 h.p., and has made regular passenger trips on Lake Zurich since the summer of 1909. It is a converted steamer, the weight of the previous steam plant, including coal and water, having been 14,700 kg. (14.16 tons) for 120 km. (64.6 sea miles) radius. The weight of the new plant for the double power and 1200 km. (646 sea miles) radius is (10-fold) 9750 kg. (9.6 tons). The cost of fuel is one-fourth of the previous cost, and the saving in labor is one man. The cost of fuel per km. is 10.5 cents (1.6 d.) per mile.

Fig. 37 shows the German tug *Fortschritt*, of 150 h.p., in Hamburg harbor. It has also made very stormy voyages on the open sea and carried fuel for eight days. The gain in length is one-third

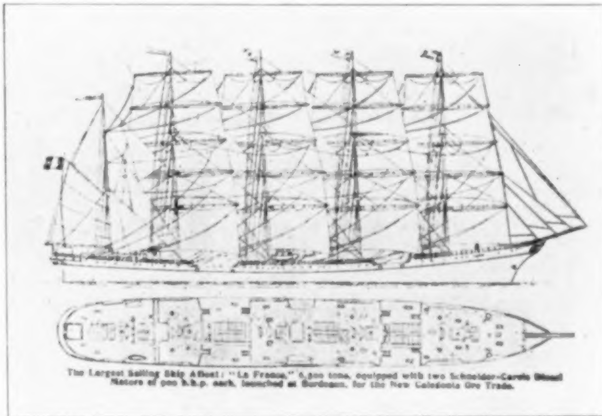


FIG. 38 SECTIONAL VIEW OF MOTOR SAILING VESSEL *La France*

over a steamer; gain in weight of machinery, about one-fourth over a steam plant; weight of fuel, only 20 to 25 per cent of weight of coal for the same power in a steamer.

The Russian tug *Jakut* has a towing capacity of 4000 tons. The engines are 320 h.p. and have worked satisfactorily for two years. The manoeuvering power is better than with steam engines. The *Jakut* and a steam ice breaker went to the assistance of a ship and towed her out of the ice, on which occasion the fuel consumption of the *Jakut* was 4380 kg. (9654 lb. or 4.3 tons) as compared with 32,500 kg. (71,630 lb. or 32 tons) by the steamer.

The *San Antonio* is the first sailing boat with a Diesel motor of

200 h.p. It navigated between the Baltic and the Mediterranean and proved so satisfactory that quite a new type of ship, the auxiliary motor sailor, is now being developed on a very large scale.

The *Quevilly* is another motor sailor of about 6500 tons displacement and 600 to 700 h.p. on two propellers. The propellers can be

FIG. 39 POLAR SHIP *Fram*

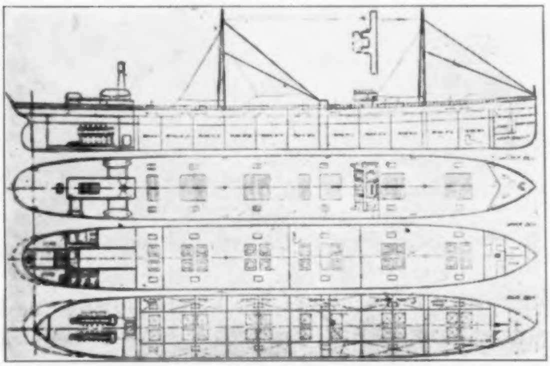


FIG. 40 OIL TANK VESSEL BUILDING BY KRUPP

uncoupled when using only the sails, and their resistance when running light causes a loss of one-half a knot in speed. It was the first ship with Diesel engines to cross the Atlantic, sailing from Rouen to New York and back in March 1911, the engines working during 1200 hours. She made a sensation entering New York

harbor under her own power and without the help of a tug. The second voyage was made in July and August 1911, and the cost of fuel was $1 per hour per engine, a very satisfactory result. The third voyage was between Havre and New York and lasted 38 days, during 26 (650 hours) of which the engines worked against a strong wind. The vessel takes its fuel in New York for the double journey at a price of $7.50 to $8 per ton. After the very good experience of this ship the owners are now building another motor sailor.

Fig. 38 is a view of *La France,* the largest sailing vessel in the

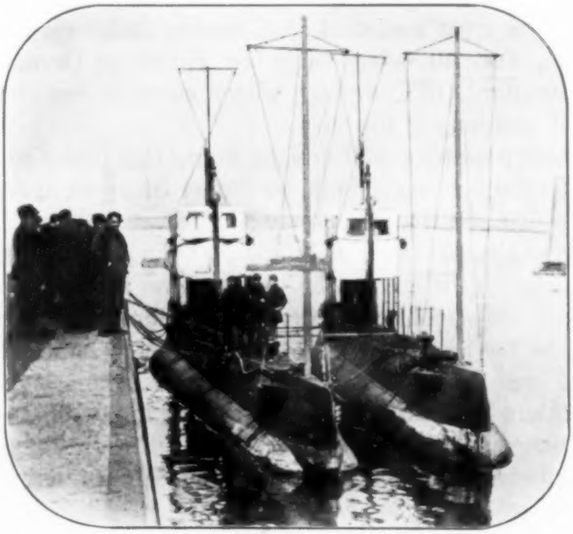


FIG. 41 FIRST TWO UNITED STATES SUBMARINES, E1 AND E2

world. It has five masts, 10,730 tons displacement, length 131 m., 1800 to 2000 h.p. in two engines, and sail area 69,966 sq. ft. It runs between France and New Caledonia for the Caledonia ore trade and was launched on November 16, 1911.

Fig. 39 shows a small but most interesting motor sailor, the old north polar ship *Fram,* fitted with Diesel engines. The gain through replacing the steam engine by the Diesel engine is: in engine space, 45 per cent; in weight of engine, 60 per cent; in weight of fuel, 80 per cent; in space for fuel, 85 per cent; several years' supply of fuel can be stored. Of 380 tons cargo capacity, 100 tons were previously required for the coal storage. The *Fram* sailed for six months from Christiania to the south polar regions without touching land and

without reporting. During the voyage to the Antarctic, the engine worked for 2800 hours without giving trouble. On March 13, 1912, Captain Amundsen, on his return from the South Pole, wired only these few words, "Diesel motor excellent."

The Russian oil tank vessel, *Djelo,* 5700 tons displacement, 1000 to 1200 h.p., made several stormy voyages on the Caspian Sea in the year 1911. It embodies the special features of the Diesel ships: a clear deck from one end to the other, no funnels, only two small exhaust pipes on the stern with invisible exhaust; engines on the rear end of the ship, with ship body free for cargo.

There are a great many oil tank vessels under construction, the largest one, Fig. 40, being built by Krupp in Germany for the German Standard Oil Company, with a carrying capacity of 15,000 tons of oil and length 160 m.

The latest passenger and freight boat, the *Borodino,* with two engines of 1200 h.p. each, built by Nobel Brothers, made her tests toward the end of 1911. There are six of these boats in commission and a ship of the same kind is building at the present time at Cockerill's in Belgium for use on the Congo River on order of the King of Belgium. This will be the first Diesel ship on colonial rivers.

Today the navies of the world have adopted almost exclusively the Diesel engine as the motive power for submarines, after the pioneer work in that direction had been done in my offices in Munich in connection with several engineers of the French navy.

The submersible boat *Hvalen* for the Swedish navy was constructed by the Fiat Company of Spezia, Italy. This is quite a modern boat of 185 tons displacement, and is propelled by three sets of Diesel engines. She left Spezia on July 30, 1911, and arrived at Cartagena, Spain, August 2, 1911, having covered a distance of 790 nautical miles without stopping. She then went to Portsmouth, thence to Kiel and Stockholm. The complete voyage of 4000 miles was accomplished without escort and without mishap. She met with extremely rough weather, but behaved very satisfactorily and won high praise from her captain, Magnussen.

Fig. 41 shows the two first United States submarines, E-1 and E-2, fitted with Diesel engines.

The new Russian gunboat *Kars,* of 1000 h.p. on two propellers, six cylinders, four-stroke, was tested in 1911: The consumption of fuel with full load in 100 hours was 1200 lb. against 4500 to 5000 lb. with coal.

In the case of torpedo boat destroyers equipped with Diesel en-

gines and with steam power, it is of particular importance that in the Diesel ship the engines are entirely under the armored deck, while in the steamship the steam engines and boilers must reach up nearly to the upper deck, and furthermore the deck is surmounted by the smoke stacks. The upper deck of the Diesel ship is perfectly free, permitting a much stronger gun equipment. The space for the Diesel engines is one-half that for the steam engines and boilers, which increases considerably the space for the officers and the crew.

Mr. Davison in England has calculated the effect of replacing the steam engine by a Diesel engine on the Destroyer *Paul Jones* of 400 tons displacement, 8000 i.h.p. engines, as follows:

	Steam	Oil
Weight of engines	449,000 lb.	317,000 lb.
Weight per b.h.p.	64 lb.	44 lb.
Radius of action at 10 knots and 180 tons fuel	1,700 knots	10,000 knots
Radius of action at 28 knots and 180 tons fuel	630 knots	2,950 knots
Fuel per b.h.p-hr. at 20 knots	2.34 lb.	0.5 lb.
Engineers and stokers	54	21
Fuel consumption in 1 year (20,000 marine miles)	2,100	360
Cost of fuel	3,840	924
Cost of engine crew labor	4,500	1,920
Cost of repairs	2,000	400

A comparison of the equipment of steam and Diesel engines for battleships made by English Navy engineers is as follows: Steamship, 4 guns of 30.5 cm., the motor ship, 10 guns of same size. In the latter case, due to the absence of funnels, each of these ten guns can be directed to nearly every point of the horizon; for instance, all ten can be directed towards one side, giving more than double the fighting capacity of the steamship. Also the smaller guns are considerably different; the steamship has only 12 smaller guns of 15 cm., the motor ship has 18 guns of 10 cm.

PASSENGER, FREIGHT AND COMBINED FREIGHT AND PASSENGER VESSELS

Fig. 42 shows a small merchant vessel, *Rapp*, cruising in the Swedish waters. The cargo capacity is 300 tons, 120 h. p. The engine runs for long periods at 55 to 60 revolutions, although the normal speed is 300 revolutions. Since 1908 the vessel has made numerous voyages between points in Sweden, Finland, Germany, Holland, England, Iceland and Norway. On a voyage from the east to the west coast of Sweden, through the canals, 75 locks had to be passed through and the manoeuvering power proved to be very satisfactory.

Fig. 43 shows the *Toiler*, the first Diesel sea-going vessel, with a cargo capacity of about 3000 tons, 360 h.p. The steering is controlled by compressed air. The cabins are warmed by water heated by the exhaust from the engines. The first voyage from the Tyne to Calais with a cargo of coal was made in very bad weather in the summer of

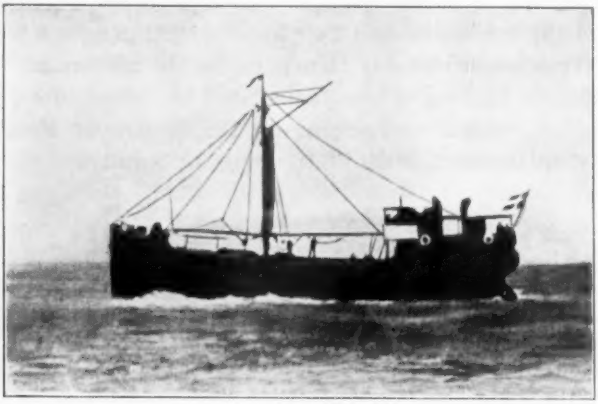


FIG. 42 SWEDISH MERCHANT VESSEL *Rapp*

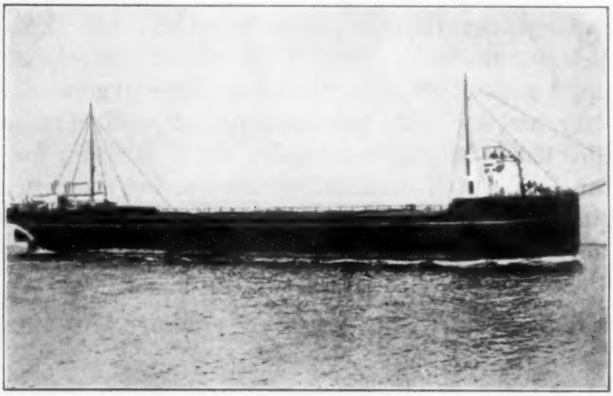


FIG. 43 PASSENGER AND FREIGHT VESSEL *Toiler*

1911. The oil consumption was 1.65 to 1.75 tons in 24 hours. A steamer of the same size would consume 8 to 9 tons of coal per day, 6 times more. The saving in cost of fuel as compared with a steamer shows 50 per cent gain in cargo capacity, 60 tons. In a voyage to North America in September 1911, the fuel consumption was 2

tons per day. The saving in cost of fuel as compared with a steam plant was $11; the saving in labor cost $5 per day. The manoeuvering power proved to be very satisfactory.

Fig. 44 shows *Romagna*, of 1000 tons displacement, 800 h.p., put in commission September 1910, making regular voyages on the Adriatic Sea between Ravenna, Trieste and Fiume in the Summer of 1911. In consequence of the faulty loading of the cargo, this beautiful vessel sank in a terrible sirocco in November 1911.

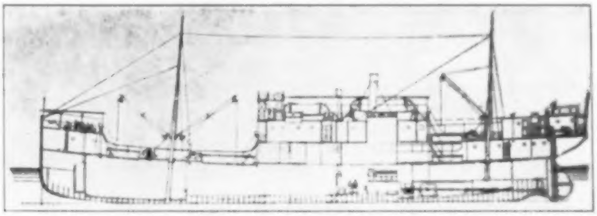


FIG. 44 LONGITUDINAL SECTION OF *Romagna*

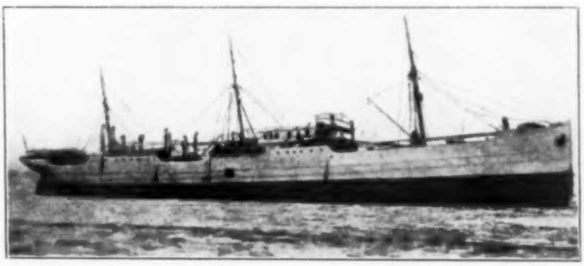


FIG. 45 DIESEL LINER *Selandia*

A Diesel engine Hamburg-American liner of 5600 tons is under construction at the Aktien-Gesellschaft, Weser, of Bremen. She will have two Diesel motors of about 2000 i.h.p. and will be delivered to her owners about the middle of this year.

Fig. 46 shows in a peculiarly striking, although in a somewhat popular form, the advantages of the Diesel plant in the freight and passenger ship *Jutlandia*, which is now being completed by Messrs. Barclay, Curle & Company and will run between Europe and Siam. It is a peculiar coincidence that 100 years separate two such events as the introduction of the marine steam engine on the River Clyde

and the launching at Glasgow of the first Diesel liner built in the United Kingdom. The ship is of 5000 tons displacement and will have engines of 3000 h.p. The fuel is carried in the vessel's double bottom. The accommodation for her passengers will be excellent. She will have magnificent staterooms, each fitted with its own bathroom, and a large dining saloon, smoking and music rooms. This luxurious accommodation is possible because of the space saved by the Diesel engine. This ship has no dangerous steam mains, the dreaded and dirty operation of coaling is absent, and while the passengers appreciate the absence of heat from the boilers and smoke from the funnels, the owner will remember that the fireman's quarters, the

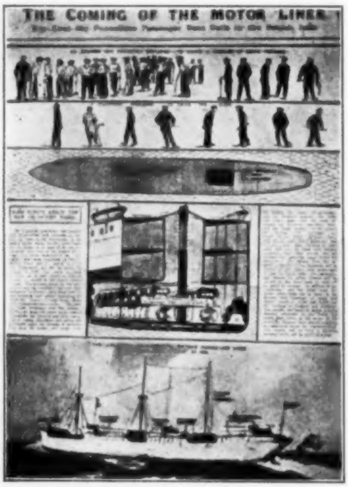


Fig. 46 Comparative Illustration of Advantages in Motor Liner, *Jutlandia*

boiler and bunker space, and the room occupied by numerous ventilation shafts and the funnel uptakes can be utilized for carrying more passengers and freight, the gain in the *Jutlandia* being more than 20 per cent. The exhaust from the engines will be carried up the hollow steel mizzen-mast so that no fumes reach the passengers.

The uppermost portion of this view shows how in place of 25 engineers and stokers in a similar steam-driven vessel, only 8 engineers will be required to operate the new Diesel vessel. The third section shows how small a space is occupied by the new Diesel engines as compared with those of a steamer. The center view shows the arrangement of the Diesel engines and the method of getting rid of

the exhaust. The lower view shows the curious headless appearance of the new ship when at sea.

Fig. 45 shows the *Selandia* of the East Asiatic Company, Copen-

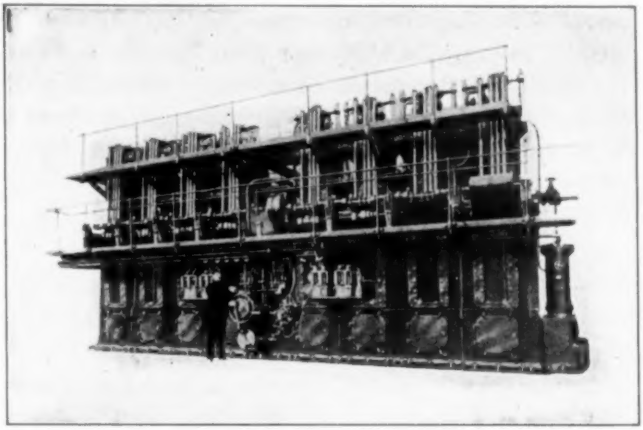


FIG. 47 VIEW OF ENGINE ON BOARD *Selandia*

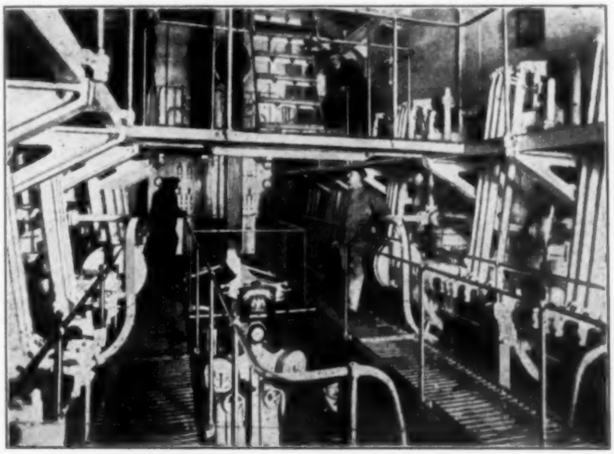


FIG. 48 VIEW OF ENGINE ROOM ON BOARD *Selandia*

hagen. This ship was in the docks of London about eight weeks ago after having been given severe trials in January in the presence of British, French, German, Italian and Russian engineers. The displacement is about 10,000 tons, length 386 ft., two main Diesel

engines aggregating 2500 h.p., two auxiliary engines aggregating 250 h.p. for the transmission of electric power to operate the winches and windlasses.

Figs. 47 and 48 give different views of the engines and the engine room. The ship has now made her first trip to Bangkok successfully. The cargo is 1000 tons more than in a steamship of similar size. The owners anticipate a saving in the fuel bill of $25,000 per annum and a gain in the yearly freight receipts of about $15,000. The East Asiatic Company has just now placed orders for 11 Diesel ocean liners of the same type and of tonnage ranging from 6000 to 10,000 tons.

LOCOMOTIVE ENGINES

Of the Diesel locomotive nothing has heretofore been published. From the early days of my invention I have been of the opinion that the special features of the Diesel engine would be of even greater importance for transport purposes than for stationary work and for that reason I have devoted much time to the development of the engine as motive power for transportation mediums. I have already mentioned that I made the first small ship engine in 1902 and that since that time the Diesel marine engine has been developed without interruption. I further mentioned that I made the first automobile engine for trucks in the year 1899, and that I looked forward to the development of this branch within a few years. Finally, I have to say that I have worked for five years, together with Sulzer Brothers, at Winterthur, and Mr. Adolph Klose of Berlin, on the construction of a Diesel locomotive, and that the first express train locomotive of 1000 to 1200 h.p. was finished a few weeks ago, and is now on the testing bed in the Winterthur shops. Five years is a very long time, and to explain why the work has taken so long, I must mention that the thermo locomotive is the most difficult problem of construction that can be taken up in the way of modern engine building, not only on account of the difficulties in starting and manoeuvering with this special kind of motor, but also on account of the limitation in space and weight. Compared with this, the development of the reversing and of the Diesel ship engine has been relatively simple. Fig. 49 shows the design of this locomotive, the car of which was made in the locomotive works of A. Borsig at Berlin. It is 16.6 m. long over the buffers and has two buggies of two axles each (1–1), and two driving wheels (2–2). The latter are not directly coupled with the engine but indirectly with the

blind axle (3) which is in the meantime the crankshaft of the Diesel engine (4).

The Diesel engine is an ordinary two-stroke cycle engine with four cylinders (4—4) coupled in pairs under an angle of 90 deg., and which drives the blind axle (3), cranks of which form an angle of 180 deg. This disposition gives complete balancing of the moving masses, the first and most important condition when putting such engines on a movable platform. Between the working cylinders are placed two scavenging pumps (5) driven by levers from the connecting rod. Beyond the engine in the roof of the car is placed the muffler (6). On the right of the main engine stands an auxiliary engine (7). This latter consists of two vertical two-stroke cycle cylinders (7-7) coupled to horizontal air pumps (8-8) driven by these cylinders. The cooler for the air compressed by these pumps is indicated at (9). These air pumps serve, according to a special and patented process, to increase the power of the main engine when starting, manoeuvering and going uphill, in such a way that auxiliary compressed air and auxiliary oil fuel are conducted into the main cylinders, by which means the diagram is enlarged, making the engine as elastic as a steam engine. For the current running of the locomotive the main cylinders work like ordinary Diesel engines without the help of the auxiliary. To the right of the main engine is placed a battery of air cylinders (10), which help the action of the auxiliary engine and which can be refilled by the auxiliary engine at times when the latter is not used. Two pumps (11 and 12) provide for the water circulation in the cylinder jackets. Apparatus for the back cooling of the water by evaporation is indicated at (13), and at (14) the tanks for fresh water and for fuel. A small donkey boiler at (15) is for the heating of the train. The channels (16) under the roof lead the fresh air to the suction pipe of the different motor and pump cylinders. The whole plant is contained in a closed engine room, which makes the locomotive look from the exterior like a modern steel car.

The engineer can operate equally well on either end of the locomotive, as the engine is arranged for running in both directions. He has a direct view of the track. Both doors and platform lead from the engine to the train.

The total weight of the locomotive in service is 85 tons. Fig. 50 gives the details of the car construction.

I cannot predict whether this attempt at an entire revolution in the working of railways will be successful at the first attempt, or whether it must be repeated, but one thing is certain to me, the

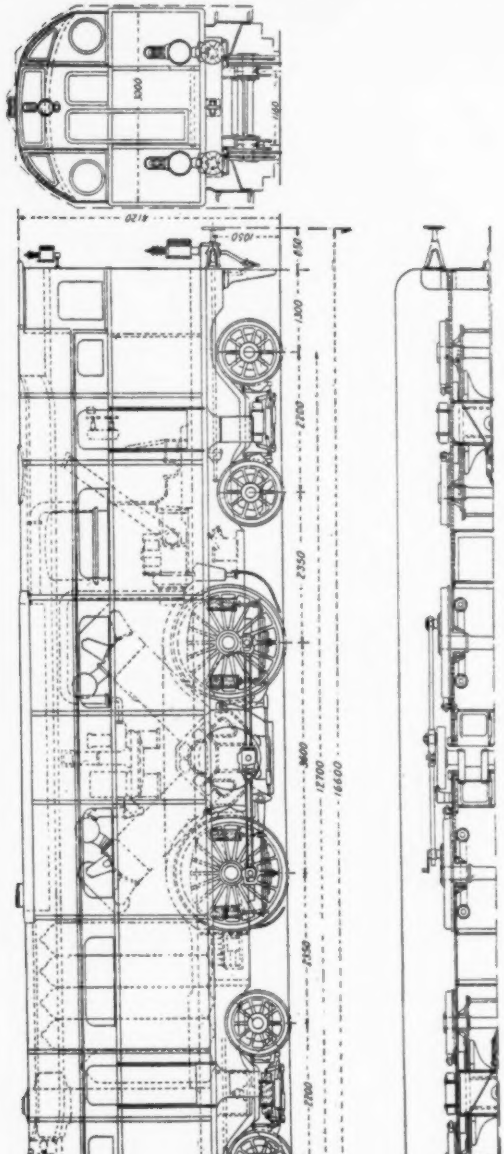


Fig. 49 Sectional Views of Diesel Locomotive

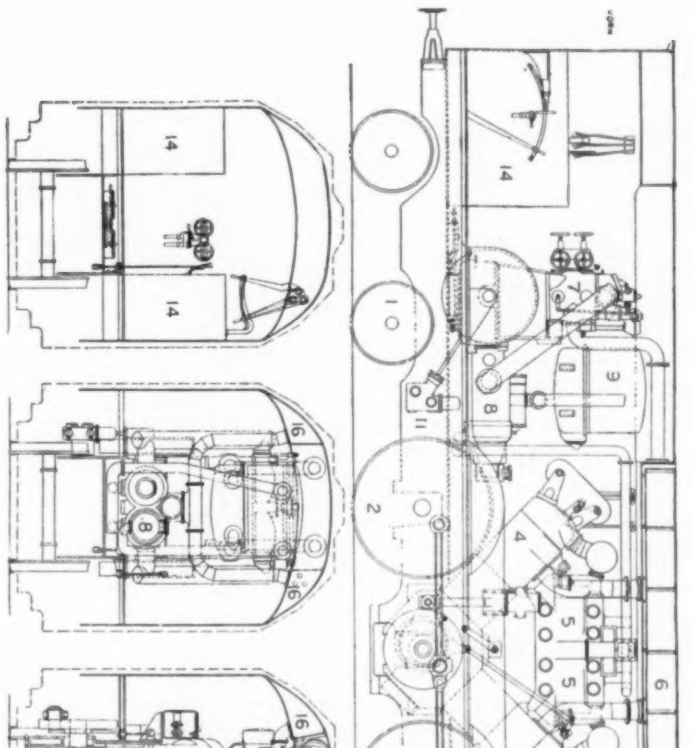


Fig. 50 Sectional View of Diesel Locomotive showing Car Construction

Diesel locomotive will come, sooner or later, according to the perseverance with which the problem is followed.

CONCLUSION

Before concluding my lecture I should like to touch upon an important question which has been put to me by the Secretary of the United States Navy, to whom I paid my first visit upon arrival in this country, and which has been repeated to me nearly every day since I left the pier at Hoboken: Why is America so far behind Europe in the development of this new prime mover, which in fact is no longer new?

To answer this I must emphatically state that the Diesel engines built in this country, after having passed the necessary manufacturing apprenticeship more than ten years ago, have been and are quite as good as our European machines. So the question is not a technical one, but merely a commercial one, or, even more, one of the general economic conditions in this country. I do not know the United States sufficiently to judge these conditions on my own behalf, but I have tried to find out in my conversation with many prominent engineers, and the following is what I could learn:

a Coal is much cheaper than in Europe, and therefore people are more wasteful with it. While the leading idea in Europe is always economy in operating cost, the leading idea in America is economy in first cost. The word efficiency, which is the base of every contract with us, seems to be unknown to a vast proportion in this country; of course, not to engineers, but to business men and to buyers of engines.

b In the same order of ideas, American steam engines are much cheaper than ours. But the Diesel engine is not and will not be a cheap engine; it aims to be the best engine and must be constructed of the highest class of materials with the most skilled workmanship. This makes it difficult for it to compete with this type of engine under the ideas which prevail. The people here are accustomed to engines of very low price, taken per pound, and the price of Diesel engines per pound seems to them exorbitant; several people have said that they would never buy an engine at that high price per pound, even with a guarantee that the whole plant would earn its cost by the savings of a few years only.

c The lack of capital on the part of the prospective purchaser in many cases, and also in many cases the higher rate of capital interest prevailing in the American money markets.

d In the last few decades the general business profits have been so large that people did not care for the most economical methods of production and for the strictest economy in the fuel bill as well as other expenses, the ruling object having been to manufacture quickly and in quantities without regard to the cost. America has not had to compete with the industrial countries of the world, as Europe has.

I have been told by American engineers that what has happened to the Diesel engine has also happened to the large gas engine, especially with blast furnace gases, and also with the steam turbine, both of which were taken up in this country long after their development in Europe.

The same has happened also with the by-products of coke ovens. Even today, the wasteful bee-hive oven is in use, while in Europe the industry of the valuable by-products earn hundreds of millions every year, and have had the tendency to keep the prices of the natural liquid fuels on a lower level.

All the conditions I have alluded to seem to be changing rapidly now; this terribly wasteful performance begins to be recognized, the competition has become more keen, and a conservation of natural resources is striven for more than ever before. If this is true, the high-class engines with the highest efficiency will begin on this side of the ocean to have the same importance as abroad. In conclusion, I hope that I have succeeded in giving a true and clear picture of the development of the Diesel engine in Europe, with a few reminiscences of the pioneer work in America. Nowhere in the world are the possibilities for this prime mover as great as in this country.

FOREIGN REVIEW

BRIEF ABSTRACTS OF CURRENT ARTICLES IN FOREIGN PERIODICALS

CONTENTS

FOREIGN REVIEW

The aim of the Foreign Review is to present, within the available space, the main data contained in the articles indexed. Where possible, reference is made to English or American publications containing fuller information on the subject treated. Measures are given both in original units and their English equivalents. In many instances, engravings and tables are reproduced. Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer.

Aeronautics

VERSUCHSEINRICHTUNGEN ZUR PRÜFUNG VON LUFTSCHRAUBEN, P. Bejeuhr. *Dinglers polytechnisches Journal*, April 6, 1912. 3 pp., 8 figs. *dh*. Description of various appliances for *testing aerial propellers*, with some historical information on the development of this branch of testing.

Air Machinery

FILTRES À AIR POUR TURBO-GÉNÉRATEURS, COMPRESSEURS ET AUTRES MACHINES. *Electro*, March 1912. 2½ pp., 5 figs. *d*. Discussion of the use of air filters with turbo-blowers, compressors, etc., and description of the Schütz filter.

ELEMENTARE BERECHNUNG DER TURBO-GEBLÄSE UND KOMPRESSOREN, R. von Stein. *Dinglers polytechnisches Journal*, April 20, 1912. *t*. Beginning of a series of articles on elementary methods of designing turbo-blowers and compressors, without the use of entropy diagrams. An account will be given later.

WIRKUNG VON VENTILATOREN UND KAPSELGEBLÄSEN, G. Lindner. *Zeits. für Dampfkessel und Maschinenbetrieb*, April 5, 1912. 2½ pp. 10 figs. *tA*. Hydrodynamic equations cannot be applied to the *calculation of ventilators and rotary blowers*, because, first, the density of the air is not constant like that of water, and, second, the flow between the blades of the rotor is unknown, the tendency being for the stream of air not to follow the curvature of the blade, but to press closer against the driving surface. The energy communicated to the air by the fan can therefore be calculated only approximately, while its blast capacity cannot be calculated from the form and speed of rotation alone at all.

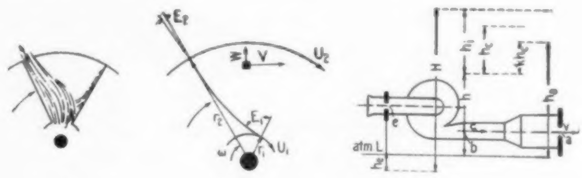
Theoretically the gain of energy can be expressed (2, Fig. 1) in meters of air by the formula

$$H=\frac{\omega}{g}(v_2r_2-v_1r_1)$$

where $v=\omega r-wtg\epsilon$ is the tangential velocity of the air, w its radial velocity, and $tg\epsilon$ is somewhat larger than at the vanes. To make this formula more convenient for practical purposes, the author expresses it in millimeters of water by multiplying it by the specific gravity of air $\gamma=1.25$ kg/cbm (therefore $\frac{\gamma}{g}=\frac{1}{8}$, and $\frac{\sqrt{2g}}{\gamma}=4$), and introducing $u_2=\omega r_2=u$, as well as $w_1=w_2=\left(\frac{r_1}{r_2}\right)c$, where c is the velocity of flow in the neck of the nozzle. He obtains finally the formula

$$H'=\frac{1}{8}u^2\left[1-\left(\frac{r_1}{r_2}\right)^2+\frac{w}{u}\left(\frac{r_1}{r_2}tg\epsilon_1-tg\epsilon_2\right)\right]-\psi u^2$$

where the factor ψ depends on the construction of the blower wheel, but varies somewhat with the flow in accordance with the vane angle. For $c=0$, and $\frac{r_1}{r_2}=1/2$ or $1/3$, $H_o'=0.09u^2$ or $0.11u^2$ respectively.



1 2 3

FIG. 1 AIR BLOWER DIAGRAM

To determine the blast capacity, the resistances in the blower have to be replaced by equivalent throttling areas, such as the orifice e in case of a suction fan (3, Fig. 1), or a similar orifice a at the pressure side in case of a blower. The throttling in e destroys a part of the atmospheric pressure in the suction chamber, and diminishes the total pressure by the amount h_e. There is a static pressure above atmospheric h on the other side, as well as velocity head h_c corresponding to the velocity c in meters per second of flow in the neck of the nozzle of cross-section b in square meters. A fraction k of this velocity head is utilized for the flow through the orifice a, and the efflux velocity at a, with efflux coefficient μ, is a function of the pressure $h_a=h+kh_c$. The capacity of the efflux is therefore

$$Q=.cb=a\mu\sqrt{\frac{2gha}{\gamma}}=4\mu a\sqrt{ha}=e\mu\sqrt{\frac{2hge}{\gamma}}=4\mu e\sqrt{h_e}$$

This equation shows also the necessary ratio of throttling $\frac{a}{b}=\frac{C}{4\mu\sqrt{ha}}$; if we accept $c=\sqrt{d}$ where d in mm is the internal diameter of the pipe fully satisfying practical demands and conditions of operation, and $\mu=0.8$ for orifices of average size, Table 1 gives practically acceptable values for $\frac{a}{b}$.

In general blowers for high pressures have $\frac{a}{b}$ equal to 1/6 or 1/4, and those for large blowing capacity $\frac{a}{b}$ equal to 1/4 to 1/2.

The energy H of the blower wheel is not equalized entirely by the static pressure above atmospheric h_e+h, and the difference h_i goes to overcome the internal resistances in the machine, and to produce the flow of air. It is convenient to express the flow in terms of the known cross-section of the neck of the nozzle b,

TABLE 1 VALUES OF $\frac{a}{b}$ FOR VARIOUS ORIFICES

d (mm)	c (m per sec.)	$h=100$	400	900 (mm of water)
		$\frac{a}{b}$		
100	9 to 10	0.30	0.15	0.10
250	14 to 16	0.50	0.25	0.15
400	18 to 20	0.60	0.30	0.20
1000	30 to 33	1.00	0.50	0.30

and to introduce a coefficient v to take care of the resistances in the blower. Then

$$c=v\sqrt{\frac{2g}{\gamma}h_i}=4v\sqrt{h_i}=4v\sqrt{\frac{H}{1+\left(\frac{vb}{\mu a}\right)^2+\left(\frac{vb}{\mu e}\right)^2-kv^2}}$$

where for $h_i=H-h_e-h$ is substituted its value from the above equations.

The coefficient $v=\mu\frac{a}{b}\sqrt{\frac{h}{H-h}}$, together with the coefficient ψ, are the two characteristic constants which can be found by testing, and which permit the calculation of the pressure and blowing capacity of a blower under all conditions of operation, if e or a are known.

The article contains also a discussion of the influence of a *diffusor*, and a method, similar to the above, for the calculation of the *efficiency of a rotary (Root's) blower*.

Firing and Furnaces

Der Irinyi-Ölbrenner für Öl-Feuerungsanlagen, Dr. S. *Gesundheits-Ingenieur*, April 6, 1912. 1½ pp., 3 figs. *d*. Description of the *Irinyi oil-burner*, and data of tests lately finished, but not yet published, by Professor Josse at the Charlottenburg Technical High School. The burner casing a (Fig. 2) is provided in its upper part with the slot f, under which is placed the retort-shaped carburetor b, having the fuel brought to it by the pipe c. Under the carburetor is placed the tray d for the initial heating fuel. The fuel flows direct into the carburetor placed in the hottest part of the furnace, and arranged so that there can be no possible back-firing into the

carburetor. The fuel is there rapidly evaporated, no air being present, the evaporation being accelerated by the foaming and expansion due to the presence in the fuel of the lighter oils. On coming from the carburetor the vapor mixes with the air drawn in by the draft in the stack, and gives a hot flame varying from red to blending white, with clean, sharp edges, free of soot. The burner can use practically any kind of liquid fuel, naphtha, naphthalin, or any of the coal-tar oils.

Professor Josse in his tests found that a burner with a carburetor of 60 mm to 80 mm (2.36 to 3.14 in.) in diameter burned without residue from 1.2 to 15 and even 20.1 (0.32 to 3.95 and even 5.3 gal.) per hr., with no coke residue noticeable. The temperature of the flame, with admission of fresh air, varied normally between 700 and 1200 deg. cent. (1292 and 2192 deg. fahr.), but by admission of preheated air any temperature employed in oil firing could be obtained. The analysis of the gases of combustion has shown the content of CO_2 as high as 13½ per cent, or an efficiency of 85 to 90 per cent, with a great regularity in the working of the burner. In fact, it is

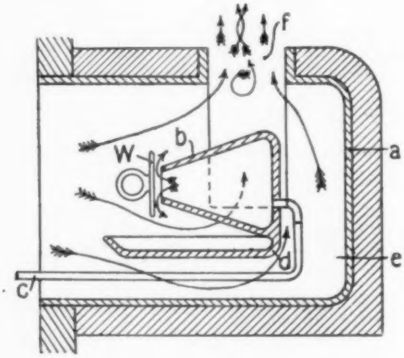


FIG. 2 IRINYI OIL-BURNER (Mark the absence of nozzles)

claimed that trouble can arise practically only owing to impurities in the fuel, and this can be eliminated by straining.

DIE REGELUNG VON MIT FLÜSSIGEM BRENNSTOFF BETRIEBENEN FEUERUNGEN, Dr. G. *Petroleum,* March 20, 1912. 1 p. *d.* Description of an *air supply regulator for liquid fuel furnaces,* arranged so that the governor of the motor driving the blower is regulated in accordance with the pressure in the oil piping in such a manner that the rotation of the blower is speeded up or retarded respectively as the oil pressure increases or decreases. The proportion of air and oil in the furnace is therefore constant under all conditions of working. The oil pump is driven by steam, and in its turn drives the oil into the pressure piping. The pressure in this piping depends on the pressure and amount of the steam entering the pump, and acts on the piston of a reduction valve in such a manner that as the pressure in the oil pressure piping increases or decreases, the piston is pressed down more or less, whereby a larger or smaller amount of steam, of higher or lower pressure,

is let through the reduction valve to the engine driving the blower, and this correspondingly affects the output of the blower so that at higher pressure in the oil piping the blower supplies a larger amount of air to the oil nozzle.

The article also describes *automatic air regulation for locomotives using liquid fuel* patented in Austria by von Madeyski and von Krobicki (the pressure in the furnace is used for regulation, with a movable piston placed in the wall of the furnace or a fire door).

Hydraulics

Die Berechnung der Flüssigkeitsreibung in Saugrohren, Düsen und Zellen von Turbinen und Pumpen und deren Einfluss auf den Wirkungsgrad, V. Kaplan. *Zeits. für das gesamte Turbinenwesen*, February 29, March 10, 20 and 30, 1912. 11 pp., 11 figs. *tA*. Calculation of *friction in draft tubes, nozzles and buckets of water turbines and pumps and of its influence on the efficiency.* The author shows that the usual method of considering friction losses as a certain percentage of the total drop without regard to the area and form of the cross-section of the respective passages may easily lead to quite misleading results, especially in the design of new units. He therefore establishes certain formulæ for the calculation of frictional resistance of water in conical draft tubes and nozzles on one hand, and runners and distributors on the other. To do this the author starts from Biel's empirical formula for the calculation of loss of pressure head in flow of water

$$h=\frac{lc^2}{R}\left[a+\frac{f}{\sqrt{R}}+\frac{b}{c\sqrt{R}}\frac{\eta}{\gamma}\right]$$

where h in mm. of water is the loss of head due to friction; c the mean velocity of flow in m. per sec.; l length of the tube in m.; R hydraulic radius expressed as the ratio of area of cross-section of tube in sq. m. to its circumference in m.; a the so-called "fundamental coefficient" (*Grundfaktor*) which, according to Biel, may be taken to be constant and equal to 0.12; f coefficient of roughness, equal to: for turbine passages 0.015, and for ordinary cast-iron and wrought iron pipes 0.019; the last element is intended to represent the variable (with temperature) viscosity of water, but in comparison with other factors may be neglected altogether according to Professor Kammerer's investigation. The author accepts therefore for his purposes the simplified formula

$$h=\frac{lc^2}{R}\left(a+\frac{f}{\sqrt{R}}\right)$$

from which h can be very easily calculated as long as the hydraulic radius R and velocity c remain constant. They are not constant, however, in conical nozzles, and the author derives somewhat complicated formulæ for this and similar cases, which he then applies to numerical examples. He proves that friction losses depend materially on the shape of the section through which the water flows, and shows how to find the friction losses at each point. He gives further a general solution for the problem of finding the friction losses in a passage of variable rectangular cross-section, investigates the influence of the number of vanes, and their length and height,

and proves the following general rules: (*a*) all other conditions being equal, vane friction grows in proportion to the length of vane; (*b*) when the number of vanes is doubled the friction is quadrupled; (*c*) when the width of entrance is doubled, the friction decreases more than four times; (*d*) in two geometrically similar wheels, that is, having geometrically similar buckets, the friction varies inversely as the diameter of the wheel; (*e*) a large number of vanes, even when they are very thin, have a material influence on decreasing the flow of water through the wheel; the same is true with respect to long vanes, and small entrance and discharge cross-sections. The author finally concludes that the highest degree of efficiency of a turbine or pump is reached when the least friction in the wheel and tubing is made coincident with a free-from-impact flow of water through the entrance and discharge passages of the wheel.

Internal Combustion Engines

Die Internationale Ausstellung von Verbrennungsmotoren in St. Petersburg. N. Bikoff and G. von Doepp. *Die Gasmotorentechnik*, April 1912. 6 pp., 14 figs. *d*. Continuation of the description of the *internal-combustion engines* at the International Exhibition at St. Petersburg. Description of the Gueldner engine and Richet gas producer built by the Kolomna works, Russia; the engine built by the Campbell Co., of Halifax, England, and the engine and Pierson producer of the Thomassen Co., of Arnheim, Holland, with data of tests of the last two types.

Versuchsprotokoll über die Vergasungsversuche mit Wackersdorfer Rohbraunkohle auf dem Stahlwerk Mannheim in einem patentiertem Drehrost-Gasgenerator System Hilger von 2100 mm lichtem Durchmesser. *Braunkohle*, March 29, 1912. 1 p. Data from tests of a Hilger Revolving Grate *Gas Producer with lignite coal containing* 52.7 *per cent moisture, and about* 60 *per cent culm*. There was obtained 1.6 cbm of gas per 1 kg of coal (25.5 cu. ft. per lb.), with an average lower heating value of 1100 Kal./cbm (say 125 b.t.u. per cu. ft.). The gas was found to be rich in moisture and tar, but comparatively poor in sulphur. The efficiency of the producer is claimed to be 80 per cent.

Versuche an einer Sulzerschen 300 pferdigen Dieselmotoranlage mit Abwärmeverwertung, J. Cochand and M. Hottinger. *Zeits. des Vereines deutscher Ingenieure*, March 23, 1912. 5 pp., 17 figs. *e*. Data from tests of a 300-hp. Diesel engine with the utilization of heat of exhaust gases in two water heaters of 30.24 qm (say 323 sq. ft.) heating surface. The article gives heat balances for the engine at various loads, as well as curves showing the mechanical efficiency of the installation, etc. These tests have shown that as much as 80 per cent of the heat contained in the fuel may be usefully employed.

Benzinmotor und Hochdruckzentrifugalpumpe der Frankfurter Feuerwehr in einem Dauerbetriebe, Schänker. *Der Motorwagen*, April 20, 1912. 1 p. *ep*. In the summer of 1911 the excessive heat forced the consumption of water in the city of Frankfort from 70,000 cbm to 110,000 cbm, an amount considerably in excess of what the machinery of the water works could deliver. There was however a well with good water avail-

able, but the water being 15 m (49 ft.) deep, and because of certain local conditions the use of a steam pump was very inconvenient. A rapid solution of the problem was required, and the city water works borrowed a 45-h.p. benzine motor and pump from the fire department, which was ordered by the latter, but not yet accepted. This was lowered into the well. The article gives full data of the rather unusual work of this fire engine plant, from which it is seen that the plant worked every day from August 1 to September 17, from 3½ to 23 hours a day, delivered during that time 65,939 cbm (say 2,320,000 cu. ft.) of water, and was in first class condition at the end of that period.

Ein Beitrag zur Lösung des Gasturbinenproblems, Lehne. *Die Turbine*, April 5, 1912. 1 p., 1 fig. *d.* Cp. Ein neuer Vorschlag für das Gasturbinenproblem, Jos. Schuch. *Zeits. für Sauerstoff- und Stickstoff-Industrie*, April 1912. 1½ pp. *d.* Both authors state that the main difficulty in the design of a successful turbine is the large consumption of power

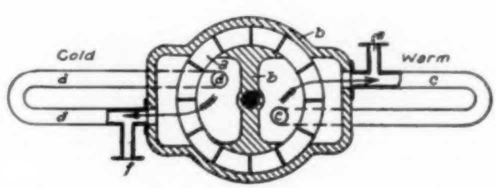


Fig. 3 Caloric Air Compressor for Gas Turbines

required by auxiliary apparatus for compressing the mixture. A new construction is therefore proposed, on the principle of the caloric engine, in which the compression of the mixture is to be obtained by preheating the air by exhaust gases. Fig. 3 shows diagrammatically the proposed construction: *a* is a wheel provided with cells opening inside and out, and revolving in a casing *b*. This casing is provided with suitably located passages which in connection with the pipes *c* and *d* form independently closed circuits. When the wheel is set into rapid rotation it acts like a centrifugal blower, that is, the air in the wheel flows outwards, so that the air contained in each of the cells is driven out and replaced by the air brought inside the wheel by the pipes *c* and *d*. The piping *c* is heated, and *d* cooled, and therefore the cold air goes from *d* to the wheel, and from there is driven to *c*, where it is heated and receives a corresponding increase of volume or pressure, the latter allowing part of it to escape through *e*, and in consequence the air entering the wheel from *c* does not have the same specific weight that it had before. Now when the air is cooled to its initial temperature in *d*, there is a fall of pressure and an aspiration of outside air through *f*. The warm air escaping through *e* goes to a cooler where it is cooled by decreasing its velocity of flow. Theoretically, by having a sufficient number of compression chambers, any degree of compression may be obtained. The wheel has to supply only the work required for making the air circulate, but the main work of compression is obtained by the application of the heat of exhaust gases. The author admits the existence of

constructive difficulties in the execution of this turbine, such as packing the wheel. It is evident from the general tenor of the article that no such turbine has ever been constructed.

DIE CHARAKTERISTISCHEN KURVEN DER DIESELMOTOREN, A. Balog. *Die Gasmotorentechnik*, April 1912. 2 pp., 4 figs. *t.* Discussion and method of construction of *characteristic curves for Diesel engines.* By a characteristic curve, or simply characteristic, the author means a curve which, when suitably interpreted, would show the limits of application of an engine as regards working conditions and completeness of combustion. In testing a motor, attention is primarily directed to determining its consumption per h.p.-hr., *ge*, indicated average pressure *pi*, and general mechanical efficiency of the engine. These values are put in the form of a diagram with *Ne*, or effective horsepower, as abscissae. If the number of revolutions varies, a whole family of such curves is obtained. In Fig. 4 with *pi*, or average indi-

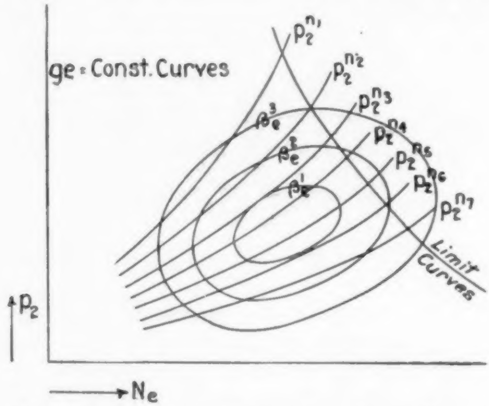


FIG. 4 CHARACTERISTIC CURVES OF A DIESEL ENGINE

cated pressures as ordinates, the number of revolutions for each set of determinations is taken to be constant, so that a separate *pi* curve is obtained for each number of revolutions. On each curve are marked the points where the values of *ge*, or consumption per horsepower-hour, are equal. If such corresponding points on all curves be connected, new curves, of equal consumption per horsepower-hour, are obtained. These *ge*-constant curves must of course be closed, and cannot intersect each other. By testing the average pressure *pi* and combustion coefficient *ge* for given speed of rotation, points can be found at which smoke in the exhaust gases appears. If these points are plotted on the *pi* curves, and connected with each other, the smoke-curve is obtained indicating the limit up to which the engine has a practically complete combustion. In the same way useful curves may be drawn with *ge* as ordinates; these *pi*-constant curves are also closed curves which do not intersect. The author claims that these two sets of curves can show everything that is necessary to judge of the efficiency and quality of an engine. He gives in the article two sets of curves based on the data obtained from the tests of Diesel engines by Eberle and Seiliger.

Kraftgasgeneratoranlage mit wechselweisem Verkokungsbetrieb für bituminöse Brennstoffe. H. L. Braunkohle, April 12, 1912. 3 pp., 5 figs. *d.* Description of a *power gas producer*, patented by Wangemann, and invented by the German engineer M. Ziegler, *in which bituminous fuels*, like peat, lignite, etc., *are treated for gas and coke in separate chambers* placed side by side, and always used for the same purpose (contrary to another type where the chambers are used alternately for gas production and coking). This arrangement permits either of the use of the gases formed in the hottest part of the gas producer chambers for heating the coking chambers or of conducting to the producer shaft the product of incomplete combustion from the coking chambers. The plant is supposed to be used primarily in places where the demand for power on the gas engine is intermittent, as e. g., in central station work when the demand for gas for the engines is small, and the plant is still working at its full capacity, only in making coke.

The cycle of operation of such an installation is as follows: The fuel is placed in the upper part of a very tall producer shaft, and entirely freed from moisture and tar; the coke is then further gasified in the lower part of the producer. To enable the plant to produce alternately coke or gas, suitably arranged chambers are so connected with each other that the gasifying chambers are provided, above the zone of incandescence, with ducts for the passage of gases, which first heat the walls of the coking chamber, and then pass into it. When the process is reversed, and the plant works as a gas producer, the same arrangement permits the full utilization of the products of incomplete combustion of the coking chamber. The article contains a detailed description of the plant with drawings. The following shows the output of the plant as gas producer and coking plant.

As a coking plant. It can treat in three coking chambers 600 kg (1320 lb.) of peat, with 25 to 30 per cent moisture, and the following production per hour:

	Kg.	Lb.
Peat coke	200	440
Ammonium sulphate	2.4	5.3
Methyl-alcohol	1.2	2.6
Peat-tar	20	44
Asphalt	20	44

and besides, 120 cbm (4200 cu. ft.) of gas, with heating value 2400 WE/cbm, or 270 b.t.u. per cu. ft. In the second coking an additional 100 kg (220 lb.) of peat is treated per hour, giving 23 kg (56 lb.) of peat coke and 20 cbm (say 700 cu. ft.) of gas. The producer and peat tar can be further treated, and give 5 per cent benzine, 75 per cent Diesel motor oil, and 10 per cent paraffin.

As gas producer. Four gas producer chambers can treat 2000 kg (2.2 tons) of peat with 25 to 30 per cent moisture; 1000 kg (2200 lb.) of such peat with about 1 per cent nitrogen give about 2000 cbm (say 75600 cu. ft.) of gas, with heating value 1200 WE per cbm (say 136 b.t.u. per cu. ft.). Since a large gas engine requires about 2.5 cbm (88 cu. ft.) of such gas per h.p.-hr., the amount of gas produced is sufficient for 1600 h.p. or 1176 kw.

As by-products about 40 kg (88 lb.) of ammonium sulphate, and 20 kg (44 lb.) of producer tar are obtained.

Gassogeno per gas povero a combustione rovesciata. L. Jacobitti. *L'Elettricista*, April 15, 1912. 3 pp., 1 fig. *d.* Description of a new *gas producer* invented by the author of this article. The fuel is charged through suitably arranged hoppers from above. Immediately below the charging space is the combustion zone provided with an inclined grate; the fuel is burned in a restricted space at a high heat with the admission of air and steam. *The gases being drawn downwards*, have to pass a second incandescent zone with the grate inclined at an angle of 90 deg. to the grate in the first zone, and then a third zone, with the grate parallel to that in the first zone, where all the carbon dioxide is reduced to carbon monoxide. On coming out from this part of the producer, the gas presumably consists of hydrogen, non-condensible hydrocarbons rich in hydrogen, carbon monoxide and nitrogen. The amount of steam required for this producer is said to be very small. The main peculiarities of this producer are: the gases travel downward just as the fuel; the products of distillation have to pass through the whole mass of incandescent material which results in the complete combustion of the coal previously freed from all volatile constituents; the coke required for the reduction is furnished by the upper part of the producer itself.

Machine Design and Machine Parts

Rapport sur les Courroies "Titan" en cuir armé système Magaldi, L. Masson. *Bulletin de la Société d'Encouragement pour l'industrie nationale*, March 1912. 13 pp., 12 figs. *dg.* Description and general discussion of the Titan belts, based on data furnished by the manufacturers. These belts are made of thongs of leather connected into strips of equal breadth, the strips in their turn being interconnected in pairs by staggered metal members. It is claimed that such a belt forms no air cushion, is very strong and flexible. No data of tests are reported in the article.

La lubrificazione delle machine utensili, G. Rinder. *L'Industria*, March 31, 1912. 1 p., 2 figs. *p.* Inefficient *lubrication in machine tools* is the principal cause of their rapid decay. It is the secondary parts which get out of order most easily, chiefly because the main parts are provided with sufficient and continuous lubrication, while the secondary parts are left to be lubricated by the workman squirting oil through a hole in the frame from time to time. But the hole becomes clogged with dirt, and the workman, who does not possess now that love of his machine which made him formerly anxious to keep it in good order, is apt to let it run dry, and spoil it. That did not matter much as long as the speeds were low, and power small, but is a very important factor under the present conditions. Some American manufacturers are beginning to construct machine tools with automatic lubrication throughout, but this practice is not yet as general as it ought to be.

Machine Shop

Fraiseuse horizontale, P. B. *Portefeuille économique des machines*, April 1912. 2 pp., 7 figs. and 1 plate of drawings. *d.* Description, with de-

tailed drawings, of a *milling machine* constructed by the Société Française des Constructions mécaniques, of Denain, France. This machine is designed to work any surface independent of its shape or size. It has a cutter rotating about a horizontal axis parallel to the plane of the machine, and cut either from one block of special steel, or made in parts with inserted teeth, and either cylindrical, or of irregular shape. The use of such a cutter permits not only of cutting over the whole surface, but of taking a very deep cut, and giving at once the desired shape to the surface milled.

PLAQUES-RESSORTS, POUR PRÉVENIR LE DESSERAGE DES PIÈCES ASSEMBLÉES PAR BOULONS. *Le Génie Civil*, March 30, 1912. *d*. These *washer-springs* (Fig. 5) are made of three pieces of spring steel welded together in the form of a triangle with a hole inside just large enough to let the bolt pass, but without giving it much play. They very strongly *resist all tendency of the bolt to get loose*, and J. Reiss found that it required a power of 1500 kg (3300 lb.) to flatten a washer weighing only 55 g (1.2 lb.).

DIE THEORIE DES SCHWEISSENS VON STAHL UND IHRE PRAKTISCHE ANWENDUNG. Max Bermann. *Zeits. des Vereines deutscher Ingenieure*, March 30, 1912. 7 pp., 14 figs. *etA*. An attempt to construct the whole *art of welding* on the basis of the *theory* that the metallic contact of the smallest particles constituting the surfaces welded together is achieved through the reducing action, at the temperature of welding, of the constituent parts of steel.

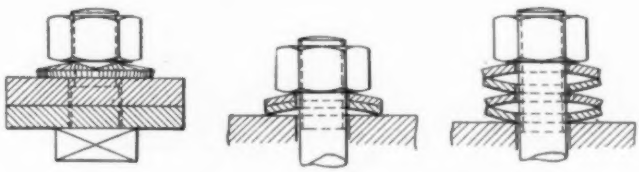


FIG. 5 J. REISS WASHERS-SPRINGS

The welding properties of steel are above all affected by the carbon content: the greater the carbon content, the less weldable is the steel, and it becomes entirely unweldable when the carbon content passes a certain limit; in the last case the reducing agents available are not sufficient to reduce all the oxides present, and the steel flies to pieces when hammered at a white heat. When, as happens sometimes, wrought iron behaves like hard unweldable steel, it means simply that under some favorable conditions it became case-hardened and so converted into hard steel. Manganese improves the welding properties of steel, but only when present as free manganese or a carbide, but hinders it when present in the form of manganese oxide. Silicon favors welding by reducing the manganese oxide, and raising the temperature of welding. Phosphorus in small amounts helps to maintain the high temperature required for welding, and thus coöperate with silicon.

The temperature of welding is the highest temperature at which steel is still malleable. The pressure required for cohesion at the temperature of

welding is slight, but after the cohesion has been effected, the blows or pressure on the two pieces must be considerable, in proportion to the size of the pieces and area of surfaces welded.

The article contains also some practical hints for welders, and a detailed discussion of autogenous welding.

EINE VORRICHTUNG ZUM PRESSEN VON ROHREN UND GLEICHZEITIGEM UEBERZIEHEN IHRER INNENWANDUNG MIT EINEM ANDEREN METALL. *Metall-Technik*, March 30, 1912. ½ p., 1 fig. *d*. Description of a process patented in Germany by the Felten & Guillaume Carlswerk Co. of Carlswerk in Mühlheim a. Ruhr, Germany, for *covering the inner surface of a pipe with a metal at the time of making the pipe itself.* As shown in Fig. 6, *a* is a conical die provided with a hollow mandrel *c*, over which the lead mass *b* is pressed into a pipe *b'*. The mandrel *c* engages into the die *d* the inner diameter of which determines the outer diameter of the pipe *b'*. On the hollow mandrel *c* is made a groove *e* connected with the inside of the mandrel by radial channels *i*. The fluid metal with which it is proposed to

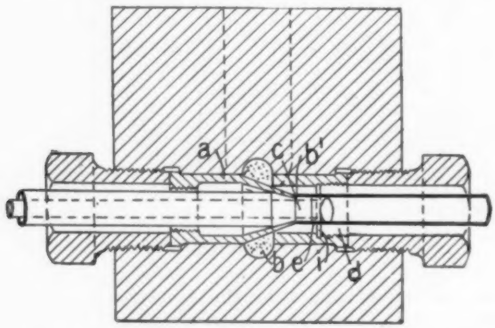


FIG. 6 FELTEN AND GUILLAUME PROCESS FOR INSIDE TINNING OF LEAD PIPES

cover the inside of the pipe is driven under high pressure into the hollow mandrel, and being thrown with considerable force through the ducts *i*, uniformly covers the inner surface of the pipe. Since at the time of the formation of the pipe it presents an absolutely clean metallic surface, and the mandrel prevents all access of air, the two metals unite under the most favorable conditions. The thickness of the metal cover, say tin, may be regulated by varying the depth of the groove *e*. This process may be applied to the manufacture of pipes of any length provided the pipe is made of metal that can be drawn.

Mechanics

SUR LE TEMPS DE DÉMARRAGE DES MOTEURS À VOLANT, Ch. Reignier. *Comptes rendus de l'Académie des Sciences*, March 18, 1912. 2½ pp., *t*. The author shows mathematically that *the time θ for starting a motor with a flywheel* (i. e. for bringing its speed of rotation from zero up to its normal speed *V*) cannot be less than a certain definite minimum for each particular case, or there will be danger

of breaking the arms of the flywheel, or the shaft of the motor. He further shows that if the curve of starting the motor is a simple half sinusoid, the arms of the flywheel are subjected to maximum tension at the end of a time ρ shorter than θ, i. e. before the motor reaches its normal speed. The author applies his method to the calculation of the stress in the arms of a flywheel of 14,000 kg (say 31,000 lb.) weight of rim, on a 275-h.p. engine, at various moments between 0 and θ, from the time of starting.

Zur Theorie der Reibung geschmierter Maschninenteile, L. Ubbelohde. *Petroleum*, April 17, 1912. 6 pp., 5 figs. *etA*. Investigation of friction in lubricated machine parts. The author in the first place proves that the wetting of journals and bearings, and the dimensions of the angle of contact are of the greatest importance in determining the lubricating qualities of a fluid. He thus introduces the consideration of capillarity. The lubricating oil forms between the bearing and journal a thin layer, the behavior of which may be investigated by means of two watch glasses. If a drop of oil is placed in one glass, and another glass of somewhat greater curvature pressed above it, the oil film may be made as thin as desired; but if we try to do the same thing with a drop of mercury, it will jump out on one side and let the air in on the other. The explanation

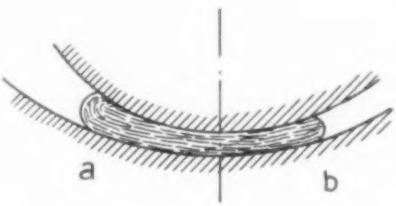


Fig. 7 Mercury Drop Under Pressure between Two Watchglasses

of this phenomenon may be found by considering the surface tension at a and b (Fig. 7), supposing that for some reason the distribution of the mercury is not uniform throughout, but that the space at b is narrower than at a. Since, however, the angle of contact is practically equal at both places, the radius of curvature at b must be smaller, and the pressure exerted by the upper glass greater than at a; the meniscus at b therefore drives the mercury to the left sufficiently to overcome the pressure at a. The mercury appears to have a "horror of narrow places." In the case of a fluid, such as oil, wetting the surrounding walls, an opposite phenomenon takes place, because (Fig. 8) in the more curved place at b the liquid is also subjected to a suction to the right which acts until the liquid is uniformly distributed in the narrowest place. In other words, the wetting liquid strives to fill the narrowest place, and this effort is so strong that under certain circumstances the liquid prevents the contact of the two contiguous surfaces. If there are air bubbles in the liquid, their behavior depends on the character of the liquid. In mercury they are driven into the narrowest space, in oil they are driven away from it.

Since, further, the capillary forces in the case of very thin films act with great strength, it follows that in using as lubricants liquids which do not wet the lubricated surfaces, there can never be any certainty that there is a liquid between

the rubbing areas. There is, on the contrary, reason to believe that there will be no liquid between them, and liquids which do not wet the surfaces in friction must not be used as lubricants. Fig. 9 shows the apparatus used by the author for investigating the capillarity of lubricants. It consists of two metal rings with watch glasses in them, and screws for bringing the rings more or less together, thus varying the pressure on the lubricant.

The author shows further, partly by a discussion of former experiments, partly

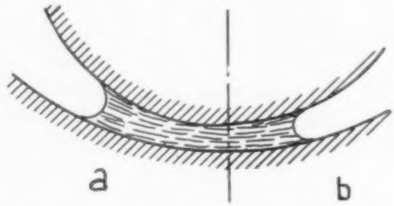


Fig. 8 Oil Drop Under Pressure between Two Watchglasses

by reference to his own observations, that *the external friction*, that is, the friction between the liquid and the contiguous solid surface, is independent of the degree of wetting and of the angle of contact, but has always to be accepted as being infinitely large, since all liquids adhere to all solid substances. External friction may therefore be neglected altogether in deriving the hydro-dynamic resistance in lubricated machine bearings, and only the viscosity of the liquid has to be considered. The author shows further that the deductions made from the experiments of Claudy on the properties of lubricants are erroneous, that there is no need for such a thing as the coefficient of adhesion derived by Claudy; that what Claudy called "capillary viscosity" is nothing but the viscosity of the liquids as compared with that of water, and that the specific viscosities of the

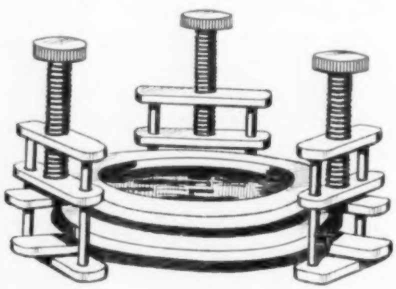


Fig. 9 Ubbelohde Apparatus for Testing the Capillarity of Lubricants

liquids agree better with Claudy's capillary viscosities than the latter do with each other.

The article contains also a discussion of the physical theory of friction between solids and between solids and liquids. It is to be continued.

Die Bertran-Kette. *Der praktische Maschinen-Konstrukteur*, April 25, 1912. 1 pp., 6 figs. *d*. Description of a new type of silent chain called the Bertran

chain, consisting of articulated members so arranged that in a certain position the *chain acts as a rigid rod.* In Fig. 10, 1 and 2 show the form of the links. In 3 and 4 the joint guides *d* and coupling *b* are shown engaging in the pin-holes *c*, which makes the chain perfectly rigid.

Steam Engineering

Die Berechnung der Dampfturbinen mit Hilfe des spezifischen Gefälles, Guido Zerkowitz. *Zeits. für das gesamte Turbinenwesen*, March 20 and 30 and April 10, 1912. 10 pp., 10 figs. *tA*. The author shows how a *steam turbine can be designed on the basis of a few auxiliary constants, particularly the specific*

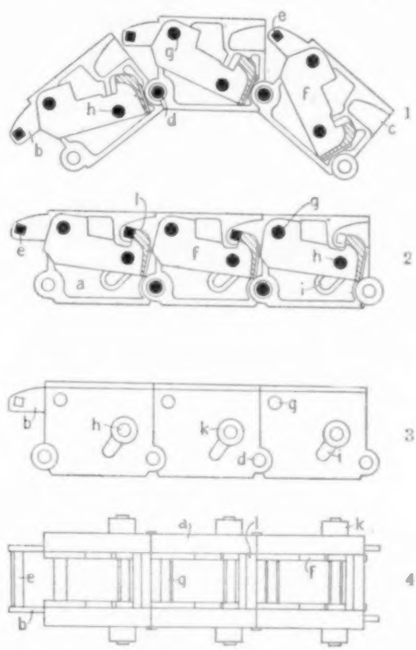


Fig. 10 The Bertran Silent Chain

drop k and mean square of peripheral speed. Among other things, in all cases with these constants the number of stages may be calculated, and all turbomachines may be classified according to their specific drop *k* ("the number of stages in different systems are related to each other directly as the 'specific sum of squares' (*spezifische Quadratsumme*), or inversely as the mean value of the specific drop." The author introduces the conception of specific sum of squares, equal to the reciprocal of the mean specific drop, as relating to the whole turbine, while specific drop as such may vary from stage to stage). There is further a connection between the specific drop and the efficiency of the turbine η. The specific drop remains constant as long as the efficiency is constant. As regards actual efficiency the author points out that the influence of mechanical losses such as imperfect joints is of more weight in small installations than in large

ones, and that is the most important reason why small turbines are comparatively uneconomical. In the case of water turbines and pumps the specific drop is also a constant, characterizing the behavior of the engine, and it is not correct to compare pumps on the basis of available pressure heads, since by doing so the dimensions of the engine and its speed of rotation are left out of consideration.

In the second part of the article the author applies his method to the designing of a steam turbine with given specific drop and mean square of peripheral speed, as well as to recalculation of actual installations on the basis of tests by Professors Stodola and Lewicki.

Turbo-Kesselspeisepumpe. *Dinglers polytechnisches Journal,* April 20, 1912. 2½ pp., 3 figs. *d.* Describes a turbine-driven feed-water pump built by the German General Electric Company. It is a single-stage centrifugal pump

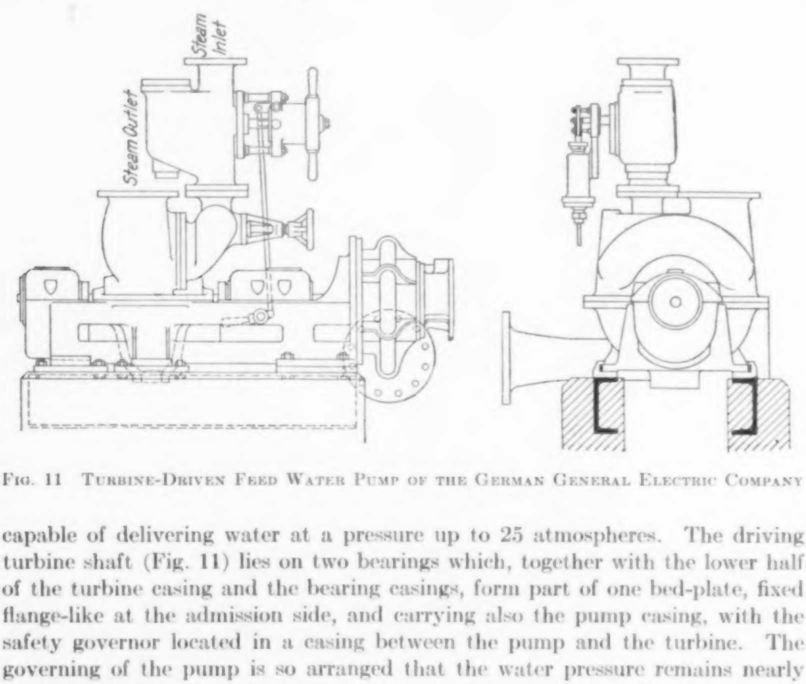


Fig. 11 Turbine-Driven Feed Water Pump of the German General Electric Company

capable of delivering water at a pressure up to 25 atmospheres. The driving turbine shaft (Fig. 11) lies on two bearings which, together with the lower half of the turbine casing and the bearing casings, form part of one bed-plate, fixed flange-like at the admission side, and carrying also the pump casing, with the safety governor located in a casing between the pump and the turbine. The governing of the pump is so arranged that the water pressure remains nearly constant, and the number of revolutions is automatically regulated in accordance with the demand for water. This is effected by means of a differential piston moving in a special casing, and having one of its sides acted on by the steam pressure from the throttling valve or direct from the boiler, and the other side open to the pump pressure. Both pressures must be equal, and should the pump pressure be greater, the piston will be forced away from it, and act on the throttling valve in such a way as to change the speed of rotation of the turbine. When the pump pressure falls off, the steam pressure forces the piston back, the throttling valve opens, and the speed of the turbine goes up.

The pump is single stage, with an overhung wheel set on the extension of the turbine shaft. The water enters the wheel axially, and is carried along pressure vanes disposed sidewise along the spirally shaped casing of the pump. The turbine stuffing-boxes are simple and are made of special steel set direct on the shaft, and provided with grooves for packing. The following advantages are claimed for this pump: small space required; low initial cost; practically no attendance required; absolute equalization of pressure in the pump; noiselessness and reliability of operation; automatic regulation of the speed of the turbine in accordance with the demand for water. The pump can work in parallel with a plunger pump, or the two may be connected in such a way that one begins to work as soon as the other is overloaded.

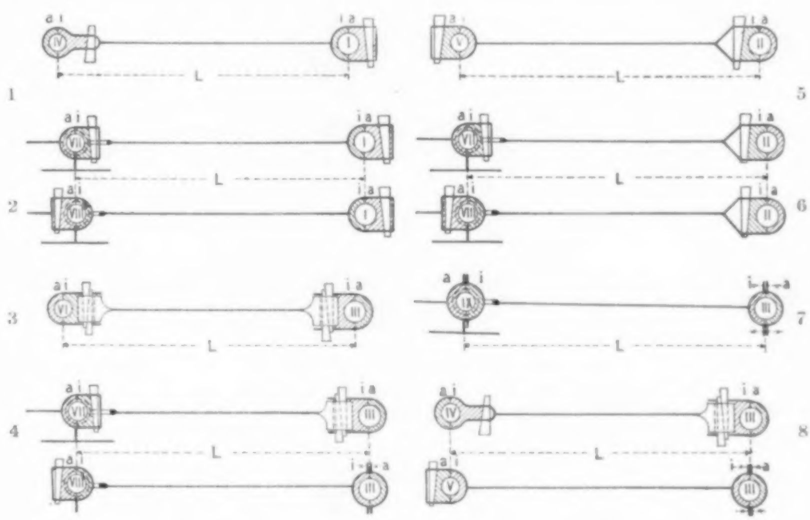


Fig. 12 Various Arrangements of Adjusting Devices in Connecting Rod Heads and Crossheads

Die Anordnung der Nachstellvorrichtungen in Schubstangen- und Kreuzköpfen, A. Wildometz. *Der praktische Maschinen-Konstrukteur*, April 11, 1912. 2 pp., 8 figs. *t*. Exposition of the methods of installing *adjusting devices for connecting rod heads and crossheads.* The requirement for a correct adjustment is that it should not change the dead centers of the piston with respect to the cylinder. Table 2 and Fig. 12 show how the adjustment affects the length of the connecting rod and the position of the piston. The length of the connecting rod L is measured as the distance from the center of the crankpin to the center of the crosshead pin. The external brass (i. e., the one lying beyond the length L, or outside of the two pins) is designated by a, the internal by i. The arrow pointing to the right indicates the displacement of the piston towards the crankshaft, the other arrow its displacement in the opposite direction.

Connecting rods with closed heads at both ends. In 1 is shown a connecting rod with heads as indicated. If the head I requires an adjustment owing to the brasses *a* and *i* being worn, the brass *i* will have to be brought closer to the crankpin (which is considered fixed), and therefore the head I will move to the right, and draw after it the crosshead and piston, which in its turn will lead to shortening of the rod and displacement of the piston towards the crankshaft. Should an adjustment of the brasses be made in head IV *a* will approach the crosshead pin, the rod will be lengthened, and the piston moved from the crankshaft. Therefore the change in the length of the connecting rod produced by adjusting the brass *i* in head I can be at least partly compensated for by the adjustment of the brass *a* in head IV, and if both these brasses have worn equally, the length of the connecting rod and position of the piston will not vary at all. The same would happen with the connecting rod shown in 5. But if the rod had on one side head I, as in 1, and on the other side head V, as in 5, an adjustment

TABLE 2 CROSSHEAD AND CONNECTING-ROD HEAD ADJUSTMENT

Kind of Head	No.	Form of Head	*L* after Adjustment		Place-Displacement of Piston in Adjustment	
			a	*i*	*a*	*i*
Connecting-rod head crankshaft side	I	Closed head, external adjustment	=	<	0	→
	II	Closed head, internal adjustment	>	=	←	0
	III	Open head, internal adjustment	=	<	0	→
Connecting-rod head, crosshead side	IV	Closed head, internal adjustment	>	=	←	0
	V	Closed head, external adjustment	=	<	0	→
	VI	Open head, internal adjustment	=	<	0	→
Crosshead	VII	Closed head, internal adjustment	=	=	→	0
	VIII	Closed head, external adjustment	=	=	0	←
	IX	Open head	=	=	→	0

of both inner brasses would make the rod shorter, and doubly displace the piston towards the crankshaft. Equally unsatisfactory would be the case of a rod provided with heads II and IV, as can be seen from the table. This permits of a *general rule* of having *in rods with closed heads at both ends the adjusting devices always on the same side of both pins.*

Connecting rod with closed head on the crank side and forked end in closed crosshead. In this form the crosshead pin is placed in the fork-shaped end of the connecting rod, with the brasses and adjusting devices in the crosshead itself; the adjustment, whether external or internal, does not therefore affect the length of the connecting rod, but there can be a displacement of the piston, towards the crankshaft in case VII, and the other way in case VIII. In order therefore that the piston should not change its dead centers, the connecting rod with closed head and external adjustment must connect with a closed crosshead with external adjustment, as shown in the upper part of 2, but the arrangement in the upper part of 6 is also correct, because there the connecting rod has an in-

ternal adjustment. An interesting feature of these two correct arrangements is that, provided the wear of the brasses is equal at both ends, there is no displacement of the piston owing to adjustments, even though there may be a change of length L. The following general rule therefore holds good for this class of connecting rods: *in connecting rods with closed head on the crank side, and fork-shaped end of connecting rod in closed crosshead, the adjusting devices must be on different sides of the pins, but both either external or internal.*

From the table and 4 it may be seen that *in connecting rods with open head, and*

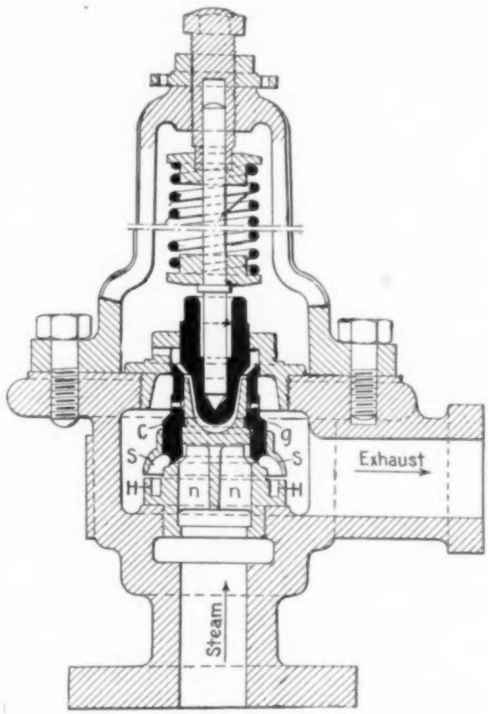


Fig. 13 Maneby Safety Valve

crosshead pin in closed crosshead, the adjusting device in the crosshead must always be external.

Connecting rod with open head on the crank side, and closed head on the crosshead side. As seen from the table, the upper arrangement in 8 is correct because an adjustment does not produce either change of length of rod or displacement of the piston, as would be the case with the lower adjustment: *the adjusting devices must therefore always be internal.*

Connecting rod with both heads open must not be used at all, because both III and VI produce shortening of the rod and displacement of the piston towards the crankshaft. The arrangement shown in 7 is also bad, because the crosshead

and piston rod are forged in one piece, and an adjustment produces displacement of the piston towards the crankshaft.

The above may be expressed in the following four general rules: (*a*) with closed heads external adjustment produces lengthening, internal shortening of the rod; (*b*) with open head internal adjustment produces shortening of the rod; (*c*) with closed crosshead internal adjustment produces a displacement of the piston towards the crankshaft, external in the opposite direction; (*d*) adjustment of the brasses in an open crosshead produces displacement of the piston towards the crankshaft.

Soupape de sûreté, système Maneby, à charge réduite et à échappement progressif. *Le Génie Civil,* March 30, 1912. ½ p., 2 figs. *d.* Description of a new *safety valve* designed by a Swiss engineer *Maneby,* and built on the principle of making the steam act on a narrow annular strip, so that a very light load is sufficient to counteract the boiler pressure. The two seats (Fig. 13) are placed horizontally, and connected by guide vanes n with the main seat H, so as to form practically one piece with the guide block g on the cylindrical part of which rests the valve C. Equalization of partial vacuum is effected by the reaction of the exhaust steam which strikes the inner curved surface of the bell S forming part of the valve, but adjustable as to height. The following advantages are claimed for this safety valve: (*a*) the load which must act on the spring at the moment of the opening of the valve, so as to balance the boiler pressure, is reduced to one-fourth or one-sixth of that usually required; (*b*) the partial vacuum produced at the moment of the opening of the valve is compensated for by the reaction of the exhaust steam striking the inner curved surface of the bell S, so that, with the amount of steam under this bell increasing as the valve rises, its rise is effected gradually until the end of its path, but as soon as the excessive pressure is relieved, the valve as gradually and without shock comes back onto its seat; (*c*) owing to the great output of these valves, their section of orifice need be only about one-third of that formerly adopted by the French practice, which permits of smaller dimensions and considerably lower cost of the apparatus.

Examen des recherches de M. Armand Duchesne sur les propriétés de la vapeur d'eau surchauffée, V. Dwelshauvers-Dery, *Revue de mécanique,* March 31, 1912. 20 pp., 14 figs. *etA.* Account of the experimental work on the *properties of superheated steam* by A. Duchesne at the Laboratory of the University of Liège. Duchesne used a special thermoelectric pyrometer invented by himself and called a *Hyperthermometer,* consisting of (Fig. 14) very fine (0.028 mm. in diameter) silver and platinum wires joined respectively to heavy wires of the same metal Ag and Pt, so that thermoelectric couples were formed only at the points where the fine wires were soldered together. The current was measured by a sensitive ballistic galvanometer, and a special arrangement installed to place the galvanometer in circuit only for a desired length of time, e.g., 1/10 of a second. The deflection of the galvanometer would then show the average temperature during that 1/10 of a second. By means of this hyperthermometer Duchesne found that only saturated steam has a definite temperature for a given pressure, and the same temperature for all points. In superheated steam there may be different layers at different temperatures, and there may even be points where the steam is saturated. He further found that in measuring

the temperature of superheated steam the mercury oil-bath thermometer is very unreliable. He found that there was a difference between the temperature as indicated by the hyperthermometer and that indicated by the mercury thermometer in an oil bath as high as 85 deg. cent. (153 deg. fahr.) at low pressure (17,084 kg/qm, or 24.2 lb. per sq. in.), falling to 43 deg. cent. (78 deg. fahr.) at the pressure of 66,930 kg/qm, or 95 lb. per sq. in. In general he believes that in many cases where the temperature has been measured by the mercury thermometer in an oil bath, the temperature of superheat is much higher than the measurement would indicate. Where a hyperthermometer cannot be used, an ordinary mercury thermometer placed direct in the steam will show the temperature with a correctness sufficient for most practical purposes.

As regards the *law of compressibility*, Duchesne establishes the following proposition: for a given pressure, beyond a certain limit of temperature, superheated

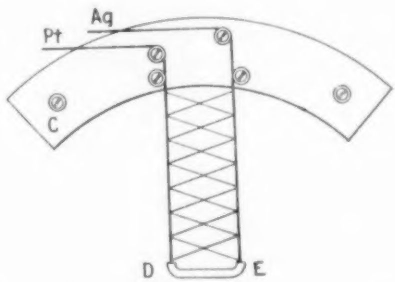


FIG. 14 DUCHESNE THERMOELECTRIC HYPERTHERMOMETER FOR MEASURING THE AVERAGE TEMPERATURE OF STEAM

steam obeys the law of Gay-Lussac, that is, at a constant pressure the product pv' is proportional to the absolute temperature T. Below this limit, down to the temperature of saturation, the law of compressibility is represented by a curve which has a point of inflection, and of which the form corresponds fairly well to a complete equation of the third degree. A general characteristic of superheated steam is that as the pressure increases, all its properties become independent of the pressure, and vary only as a function of the temperature.

The article contains also a full discussion of the variation of the specific heat of superheated steam.

KRAFTERZEIGUNG UND WARMASSERBEREITUNG, L. Schneider. *Dinglers polytechnisches Journal*, April 20, 1912. 4 pp., 12 figs. *c*. Discussion and comparison of various methods of combining steam power with steam heating. The author concludes that the most economical method is to take the steam from the receiver of a compound engine. Cp. the article on the same subject by Lecuir, *The Journal*, May, 1912, p. 789.

Strength of Materials and Materials of Construction

BIEGUNGSVERSUCHE AN GUSSEISERNEN STÄBEN, R. Schottler. *Zeits. des Vereines deutscher Ingenieure*, March 2 and 9, 1912. 12 pp., 29 figs. *eA*. From an experimental investigation of *bending of cast-iron bars*, the author concludes:

that the property of having the apparent transverse strength considerably higher than the tensile strength is not peculiar to cast iron alone. There are other tough materials in which at bending there arise apparent stresses greater than the tensile strength of the material.

As far as elasticity is concerned, cast iron shows a very irregular behavior, due probably to irregular cooling when being cast. This irregularity of behavior obscures the experimental data to such an extent that reliable conclusions can be obtained only in rare cases, especially if the span and load have been small.

Coefficients of elasticity obtained from tests with specially cast test pieces must not be applied to the design of cast-iron structures. Stresses taking place in bent bars carrying less than safe load differ from stresses calculated in the usual manner, but are by no means in the same ratio to them as tensile strength is to apparent transverse strength.

It is therefore unadvisable to accept as safe loads for cast-iron bars under flexure values which are higher than those which would be considered safe tensile stresses. The investigation of cast-iron structural parts by breaking tests is misleading; instead, elongation measurements ought to be made whenever possible, and the stresses calculated from them with a very carefully selected value of the modulus of elasticity.

The article contains full data of the tests made by the author.

Ispytanie na Yugo-Zapadnykh dorogakh babbita 83% svintza i 17% surmy (Tests on the Southwestern Railroads, Russia, of babbit metal consisting of 83% lead and 17% antimony), P. Yanushevski. *Bulletin of the Permanent Committee of the Conferences of Representatives of Russian Railroads,* February 1912. 6 p. *e.* The *babbit metal* generally used on the Russian Southwestern Railroads is made of 23% tin, 3% gunmetal, 24% antimony, 50% lead. Extensive tests were made with both the usual babbit metal, and the new one consisting of 83% lead and 17% antimony, and the following has been found:

	Specific Gravity	Hardness	Toughness	Strength
Usual babbit......................	8	23.00	18.1	34
New babbit.......................	10	20.	17.5	31

The wear of bearings was found to be practically the same with both metals, but the *new babbit is more than twice as cheap* as the former.

Thermodynamics

Der Wärmeübergang von heisser Luft an Rohrwandungen. Dr.-Ing. H. Gröber. *Zeits. des Vereines deutscher Ingenieure,* March 16, 1912. 5 pp., 8 figs. *eA.* Data of an experimental investigation, made in the Laboratory of the Technical High School of Munich, on the *flow of hot air in pipes,* and in particular on the *influence of the temperature of the pipe walls and air on the transmission of heat.*

Coefficient of heat transmission and length of pipe. The coefficient α of heat transmission which was found to be very high at the beginning of the pipe, sank very rapidly as the distance from the beginning increased, and approached a minimum at the end of the pipe (this relation was formerly proved theoretically by Nusselt).

Coefficient of heat transmission and temperature of the walls of the pipe and air. By slightly varying Nusselt's theoretical formula, the author obtains the following equation for the coefficient of heat transmission:

$$\alpha = \left[15{,}90 \frac{273^{3m-1}}{d^{1-m}} \rho_{\circ}^{m} \, c_{p}^{m} \, \lambda^{1-m} \, w^{m} \right] T_{w} \, T_{L}^{-2m} = C \, T_{w} \, T_{L}^{2m}$$

where λ is the heat conductivity of air. By substituting experimentally obtained values for α from a table given in the article, the author finds, that if α is expressed as an exponential function of T_w, or temperature of the pipe wall, and T_L, or temperature of the air, the exponents of these temperatures do not remain constant, but vary with the temperatures, and from 0 to plus 100 deg. cent. are approximately what Nusselt found, but differ considerably from his values at higher temperatures. The author believes that even at temperatures as low as 200 to 300 deg. cent. the radiation of heat of the gas is large enough to affect the law of heat transmission.

The second part of the article deals with the problem of *radiation of heat of gases*. The author begins by deriving a general formula which permits to calculate the radiation from one area through another opposite it, and through the intervening layer of air. This equation is then applied to the case of the flow of air in a pipe, and the heat transmitted by radiation is calculated as part of the total heat transmitted. When the heat is transmitted by radiation alone, this radiation formula may be applied; when it is transmitted only by radiation and conduction, the Nusselt equation should be applied, and a special law has yet to be formulated to include cases lying between these two extremes.

Miscellaneous

MASCHINENWIRTSHAFT IN HÜTTENWERKEN, Dr. H. Hoffman. *Zeits. des Vereines deutscher Ingenieure*, March 16, 23 and 30, 1912. 16 pp., 41 figs. *d*. Discussion of the modern development of machinery in metallurgical works plants, such as power stations, gas engines, blowers, rolls, etc., from the point of view of economic efficiency and reliability, with many illustrations of modern types of engines and plants.

Supplementary references:

Tosi, Steam Turbine (Foreign Review, May, 1912, p. 802) Cp. *Engineering* (London), April 26, 1912, p. 555.

GAS POWER SECTION

PRELIMINARY REPORT OF LITERATURE COMMITTEE

(XVIII)

ARTICLES IN PERIODICALS[1]

ABGASE VON GASMASCHINEN, AUSNUTZUNG. *Stahl und Eisen*, April 4, 1912. 2/3 p., 2 figs. *p*.

A mention of an appliance for utilizing the exhaust heat from gas or oil engines.

BETRIEB VON GENERATORÖFEN, DER. R. Geipert. *Journal für Gasbeleuchtung*, March 2 and 9, 1912. 10 pp., 7 figs., 3 tables.

The operation of gas plants.

COMBUSTIBLES MÉDIOCRES DANS LES MINES DU DISTRICT DE DORTMUND, UTILISATION DES. Dobbelstein. *Notes Technique de Comité Central des Houilleres de France*, April 1, 1912. 7 pp., 3 figs., 12 tables.

Utilization of exhaust gases from mines in the district of Dortmund.

DIESEL ENGINE, A NEW. *The Engineer* (London), April 19, 1912. 2 pp., 6 figs. *dmpC*.

General description with some changes in details of engine built by Franco Tosi, of Legnano, Italy.

DIESEL ENGINE DESIGN, SOME ASPECTS OF. D. M. Shannon. *Engineering*, May 3, 1912. 5½ pp., 3 figs., 3 tables. *dm*.

Paper before the Institution of Engineers and Shipbuilders of Scotland, April 23, 1912.

DIESEL ENGINE FORMULA, A NEW. P. A. Holliday. *The Engineer* (London), April 5, 1912. ½ p., 1 curve. *mpA*.

Formula for bore, stroke and revolutions per minute when required horsepower is given.

KERPELY GASERZEUGERS, ÜBER EINE NEUE BAUART DES. H. Hermanns. *Dinglers polytechnisches Journal*, March 9, 1912. 2 pp., 1 fig., 4 tables.

Describes a new type of Kerpely gas producer.

MOTEURS À COMBUSTION SANS SOUPAPE, QUELQUES. G. Richard. *Revue de mécanique*, March 31, 1912. 32 pp., 100 figs., 3 tables, 6 curves. *A*.

Valveless motors showing various types.

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[1] Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *h* historical; *m* mathematical; *p* practical. A rating is occasionally given by the reviewer, as *A*, *B*, *C*. The first installment was given in The Journal for May 1910.

ROHOELMOTORE, NEUERE. Ch. Pohlmann. *Journal für Gasbeleuchtung*, March 16 and 30, 1912. 8 pp., 24 figs.

New types of crude oil motor.

TURBINE, THE GAS. Norman Davey. *The Engineer* (London), April 5, 12, 26, 1912. 6½ pp., 8 figs., 1 table, 4 curves. *dmpA.*

Describes, with formulæ and curves, the steam and air turbine and the rotary air compressors.

TORFGASANLAGE, BERICHT ÜBER DIE UNTERSUCHUNG EINER. H. Baer. *Zeit. des Vereines deutscher Ingenieure*, April 6, 1912. 4 pp., 3 figs, 1 table, 9 curves.

Report of an investigation of a peat gas installation.

ZENTRALGENERATORGASANLANGEN IN DEN WIENER STÄDTISCHEN GASWERKEN, DIE. K. Marischka. *Journal für Gasbeleuchtung*, April 13, 1912. 6 pp., 5 figs.

Gas plant of the city of Vienna, Austria.

REPORTS OF MEETINGS

SAN FRANCISCO MEETING, APRIL 3

A meeting of the Society was held in San Francisco on April 3, at which the paper by R. E. Cranston on The Design and Mechanical Features of the California Gold Dredge was presented and discussed. Those who participated in the discussion were R. H. Postlethwaite, member of the Institution of Electrical Engineers, London, and of the American Institute of Mining Engineers; J. W. Plant, Mem. Am. Soc. M. E., engineer with the Edgar Allen American Manganese Steel Company, San Francisco; W. C. Knox; Thomas Morrin, Mem. Am. Soc. M. E., consulting engineer, San Francisco; and the author.

NEW YORK MEETING, MAY 14

The topic of Commercial Dictating Machines was discussed at a meeting of the Society in New York on May 14, in the Engineering Societies Building. The opening remarks were made by A. J. McFaul of the Allen Advertising Company of New York, who has made a study of the various methods of recording and reproducing speech, with particular reference to the increase of practical efficiency in handling dictation in offices. He was followed by C. K. Fankhauser of the American Telegraphone Company, Springfield, Mass., Otto Brushaber of the Dictaphone Company, New York, S. H. Bunnell, Mem. Am. Soc. M. E., consulting engineer and efficiency expert, New York, Q. Diepenbrock, T. C. Martin, Jr., W. W. Macon, Assoc. Am. Soc. M E., engineering editor of the Iron Age, New York, George A. Orrok, Mem. Am. Soc. M. E., New York Edison Company, New York, and H. F. J. Porter, Mem. Am. Soc. M. E., consulting engineer, New York. Demonstrations of the various machines on the market followed the meeting.

Previous to the meeting a number of the New York members gathered at dinner at the Engineers Club, thus introducing an agreeable social feature.

BOSTON MEETING, MAY 17

At a meeting of the Society in Boston on May 17, two papers were presented: Progress in Development of a New Type of Centrifugal Pump and Blower, especially for Steam Turbine Drive, by C. V. Kerr, Mem. Am. Soc. M. E., and A. L. Schaller, Jun. Am. Soc. M. E., of McEwen Brothers, Wellsville, N. Y.; and Increase of Bore of High-Speed Wheels by Centrifugal Stresses, by Sanford A. Moss, Mem. Am. Soc M E, of the Turbine Research Department of the General Electric Company, West Lynn, Mass. Both of the papers were fully illustrated with lantern slides. The papers were discussed by J. B. Sando, followed by a more informal discussion in which a number participated.

STUDENT BRANCHES

COLUMBIA UNIVERSITY

Mechanical Engineering in the Steel Industry, by Carl Meissner, was presented at the April 25 meeting of the Student Branch of Columbia University.

CORNELL UNIVERSITY

At the May 1 meeting of the Sibley College Student Branch, William H. Boehm, Cornell 1892, of the Fidelity and Casualty Company of New York, read a paper on Boiler Explosions which was illustrated by lantern slides.

LEHIGH UNIVERSITY

The Student Branch of Lehigh Univeristy held a meeting on April 11 at which the following papers were presented: Breakage of Steel Rails, by H. S. Fowler. The possible cause for the many rail breakages in winter was attributed to piping, together with possible changes of crystalline structure at extremely low temperatures; also improper counterbalancing of the locomotive producing excessive pressure on the rails during high speed. G. S. Chiles discussed the paper. R. V. Parker's paper on Future of the Steam Turbine discussed all the important types of reaction and impulse turbines and the services required of them. A paper on Variable Speed Transmission on Motor Trucks, by J. H. Sheppard, outlined the Manly system which may make possible the elimination of a large bulk of gear transmission and other controlling devices when used on motor trucks, gun mounts, etc. This was discussed by Prof. H. S. Howarth.

MASSACHUSTEES INSTITUTE OF TECHNOLOGY

At the May 8 meeting of the Mechanical Engineering Society of the Massachussetts Institute of Technology, Charles M. Mumford delivered an illustrated lecture on The Development of a Fine Goods Cotton Mill. The illustrations showed floor plans of the mill, arrangement of machinery and views of the buildings. Professor Haven and Mr. Obrien discussed the paper.

POLYTECHNIC INSTITUTE OF BROOKLYN

On April 27 the Polytechnic Institute of Brooklyn Student Branch held its first annual dinner, at which Dr. J. B. Chittenden, head of the department of mathematics, was toastmaster. The speakers of the evening were F. R. Low, Assoc. Am. Soc. M. E., President Atkinson, G. A. Orrok, Mem. Am. Soc. M. E., Chas. E. Potts, and Prof. W. D. Ennis, Mem. Am. Soc. M. E.

Jas. W. Nelson, Assoc. Am. Soc. M. E., gave a lecture on The Eight Years' Occupation of the Canal Zone by the American People Since May 1904, at the May 4 meeting. A general discussion followed.

STEVENS INSTITUTE OF TECHNOLOGY

At the May 7 meeting of the Stevens Engineering Society, the treasurer's final report for the season was read and accepted. The election of officers for the season 1912-1913 resulted as follows: chairman, John Henry VanderVeer; vice-chairman, Carleton Wandel; secretary, Jerome Strauss; treasurer, Jacob H. Bräutigam.

UNIVERSITY OF CALIFORNIA

At a meeting of the Student Branch of the University of California held on February 20, a paper on Pyrometers, by J. P. Zipf, was presented. On March 3 the Branch was addressed by E. A. Slater on Power Plants of Steam Ships. At the March 19 meeting, Prof. J. N. Le Conte, Mem. Am. Soc. M. E., spoke informally on the object and work of the Branch and delivered a lecture on the Auxiliary Fire Protection System of San Francisco. On April 3, W. P. Custer read a paper on Centrifugal Pumps. At the April 16 meeting the following officers were elected for the fall term: chairman, G. M. Simonson; vice-chairman, J. F. Ball; secretary, G. H. Hagar; treasurer, M. E. Page. A paper on Mallet Compound Engines was read by J. B. Wells, Jun. Am. Soc. M. E.

UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Branch held its regular monthly meeting on April 23 in the club room of the New Engineering Building at which reviews of the current numbers of engineering magazines were presented by the student members.

UNIVERSITY OF ILLINOIS

On April 26 the University of Illinois Student Branch held its regular bi-monthly meeting. The subject of the evening was Steam Turbines. T. E. Maury presented a paper on the DeLaval Turbine and A. T. Weydell gave an illustrated talk on the Curtis Machine. A general discussion followed.

UNIVERSITY OF KANSAS

The Southern Power Company, by Earl Rush, and The Mechanical Handling of Freight, by R. H. Forney, were presented at the April 11 meeting of the University of Kansas Student Branch.

On April 18, Prof. P. F. Walker, Mem. Am. Soc. M. E., delivered a lecture on Ideals for Engineers, and on April 25, his lecture on The Design and Manufacture of Large Ships was illustrated by lantern slides which showed the growth of the modern ship and internal construction of steel ships.

UNIVERSITY OF MISSOURI

At the April 15 meeting of the University of Missouri Student Branch a debate was held on the following subject: Resolved, That in an oil field district it is better to use the oil in internal-combustion engines than to burn it under steam boilers, for a plant of about 2000 kw. capacity. P. A. Tanner and F. I. Kemp were on the affirmative side and A. E. Heptonstall and R. M. James on the negative. The affirmative side won the debate.

NECROLOGY

ERNEST S. BOWEN

Ernest S. Bowen was born at Levanna, N. Y., May 28, 1858, and died at Geneva, N. Y., April 27, 1912. At an early age he went to work for the J. A. Spencer Iron Works, Union Springs, N. Y., where he received his first training and practical experience in mechanics. Realizing the advantage of a technical education, he entered Cornell University and worked his way through, graduating in the class of 1890. Immediately after graduation he entered the employ of the McIntosh Seymour Engine Company, manufacturers of high-speed engines, Auburn, N. Y., of which he soon became assistant superintendent. In 1895 he embarked in business for himself, forming a partnership with Walter L. Fay, also of Auburn, for the manufacture of bicycle parts. After five years they sold out, but re-formed a partnership for the manufacture of marine engines under the name of Fay & Bowen. As this business grew they added to it the manufacture of motor boats, which necessitated their moving to a location with a water front. They were attracted to Geneva and in 1904 the business was incorporated under its present name of the Fay & Bowen Engine Company and it has steadily grown until it is one of the leading concerns of its kind in the country.

JAMES P. S. LAWRANCE

James P. S. Lawrance was born in Philadelphia in 1852 and attended the Episcopal Academy in that city. He was matriculated at the Lehigh University and graduated in 1873 with the degree of M. E. He served about one year under instruction in the machine shop of John Roach & Sons, Chester, Pa., to qualify for the Engineering Corps of the Navy, which service he entered as second assistant engineer in March 1875. He made a three years' cruise on the Asiatic Station and another on the Pacific Station, also a six months' cruise on the North Atlantic Station in a sea-going monitor. In April 1883 he was ordered to duty in the office of Naval Intelligence in the Bureau of Navigation, Navy Department, and in June 1883 was

commissioned a past assistant engineer in the United States Navy. Subsequently Captain Lawrance served at the Norfolk and the Washington Navy Yards; the Homestead Steel Works and the Thurlow Steel Works. He took part in the "battles" of Cardinas and Manzanello during the war with Spain and made voyages through the Straits of Magellan, the Suez Canal, up the Amazon River about 2000 miles, and around the world. He was promoted in the regular course up to the rank of chief engineer in the Navy and by virtue of the act of Congress approved March 3, 1899, was transferred into the line of the Navy and promoted to the rank of commander. At his own request his name was transferred to the retired list June 30, 1905, which promotion carried with it the rank of captain. He died January 16, 1912.

Captain Lawrance was a member of the American Association for the Advancement of Science.

I. CHESTER G. WILKINS

I. Chester G. Wilkins was born in Whitehall, N. Y., September 8, 1871. He received his early education in the public schools of Whitehall and in 1893 was graduated from Cornell University with the degree of M. E. His first work was in the railroad shops of Whitehall, and in August 1894 he went to New York entering the employ of Evans, Almirall & Company, heating and ventilating engineers and contractors, with whom he remained until May 1895. He then obtained a position with C. O. Brown, consulting engineer, Brooklyn, N. Y., and from March 1896 to May 1899 designed heating and ventilating apparatus for public school buildings. He went to Baltimore, Md., having secured a position with Henry Adams, consulting engineer, and two years later returned to New York to fill a position with Thompson-Starrett Company, with which concern he remained till his death, April 20, 1912. His work during this period consisted in the design, specification and general supervision of installations of mechanical equipment for such buildings as James McCreery & Company's store at 9 West 34th Street, New York; the Crescent Athletic Club, Brooklyn, the Adelphia Theater, Philadelphia; the Title Guarantee & Trust Company's bank and office building, Brooklyn; the New York Steam Company's boiler house; and John D. Rockefeller's residence, Pocantico Hills, N. Y.

GEORGE H. SULZER

George H. Sulzer, chief designer and manager of the centrifugal pump department of the Worthington Hydraulic Works, Harrison, N. J., died in New York April 20, 1912. Mr. Sulzer was born in Winterthur, Switzerland, October 21, 1877. He received his early education at the public schools and industrial college of Zurich. His professional training was obtained at the Polytechnic Institute of the same town, where he received his diploma in 1902. For several years after his graduation he was assistant in the department for centrifugal pumps and turbines at the Polytechnic Institute. In 1903 he sailed for America and found employment with R. D. Wood & Company, Camden, N. J., and later on the engineering staff of the Buffalo Forge Company. In 1906 he was engaged by the Henry Worthington Company to take charge of the design of centrifugal pumps, which had always been his specialty. He had an unusually intimate understanding of the theory and construction of rotating machinery, particularly of the newer types of pumps, and his services were most valuable in the solution of special problems, even though he was often handicapped by the prevailing commercial tendencies and conditions. He was a member of the Newark branch of the Deutscher Technischer Verein, being its president for two terms. He was also a member of the Vereinigung der Schweizerischen Techniker.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for the Bulletin must be in hand before the 12th of the month. The list of men available is made up of members of the Society, and these are on file in the Society office, together with names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

0166 Wanted for New York City and vicinity, experienced salesman for iron castings, both rough and machined; to have established trade and be a man of standing and ability. Apply through Am. Soc. M. E.

0167 Salesman for boiler-plant machinery, must have experience. State references and salary expected.

0168 Assistant professor of mechanical engineering in college in middle west; to teach general mechanical engineering; line of subjects including drawing, descriptive geometry, mechanical laboratory, turbines, gas engines, power-plant design and similar subjects. Salary $1200.

0169 Any member proposing a trip to Cuba in the immediate future may secure information regarding representation in Havana of a New York concern by applying to the Secretary. Remuneration for this special service in excess of $1000 if representation is successful.

0170 Iowa concern desires manager for engineering department; good executive, capable of preparing heating plans and specifications or superintending the making of same with technical education and thoroughly reliable in every way. Apply through Am. Soc. M. E.

0171 Superintendent for factory employing about 300 men, manufacturing heating apparatus and steam specialties. Location middle west. Apply through Am. Soc. M. E.

0172 Engineer salesman for concern in New York; must understand fans, exhausters, etc.

MEN AVAILABLE

421 Member has held important positions in the manufacture of injectors, lubricators and brass steam specialties; qualified to fill a position as superintendent of works manufacturing these lines. Inventor of several improvements in jet apparatus. Some sales experience.

422 Member, 12 years' broad experience in all branches of industrial construction would like to secure position with large industrial plant as mechanical engineer or engineer in charge of construction, or with consulting engineer who

is in need of man to relieve him of responsibility and see large work through from rough sketches to operation. Best of references and testimonials. Salary $4200 to $5000 according to location. Can arrange interview in New York or vicinity. Available in July.

423 Junior member, 27, desires to change his connections. Five years' experience in steel business covering, engineering, production, costs, and selling; position in any line where hard and conscientious work will be appreciated.

424 Member, Cornell graduate, experience, ten years machine shop, six years drafting and other engineering work, five years teaching in all branches of mechanical engineering and almost all subjects usually given in that course. Capacity for organizing. Now in charge of machine design and construction. desires change.

425 Technical graduate, 12 years' experience foundry and machine shop manufacturing specialties; in charge of drafting construction and assistant executive, also some experience as salesman; past five years superintendent manufacturing plant. Some money to invest if desirable.

426 Mechanical engineer, seven years' experience in the design, construction and operation of portland cement plants, familiar with wet and dry processes; desires position with manufacturer of portland cement, would be especially valuable to concern desiring to modernize plant or to build. Now employed in a position similar to the one desired. Graduate of Cornell University, Jun. Am. Soc. M. E. Age 32, married.

427 Motor-truck engineer and designer open for proposition with progressive commercial car firm as transportation expert, efficiency man and data collector; competent to investigate, analyze and report upon prospects for truck sales in any industry, or to act in educational capacity among merchants in cities where few trucks are in use. Seven years' continuous experience in commercial car business, in drawing room, factory superintendent, publicity and editorial work.

428 Wanted position as mechanical engineer for a manufacturing plant employing about 1500 to 2000 men; can give first class references as to reliability and capability; now employed as designer of machinery but desires to make a change. Salary $3000 to $4000.

429 Junior member, technical graduate, marine and mechanical engineering, one year in night law school; age 27. Experience as factory foreman and assistant superintendent; assistant engineer and chief draftsman with a reinforced concrete steel company. Assistant engineer and superintendent of construction on factory and mill construction work. Would like to become permanently located with manufacturing or industrial concern either in technical or business way with view of working up in the business.

430 Technical graduate, would like position with engineering department of concern manufacturing steam or gas engines or consulting engineer having steam or gas engine work. Good experience in locomotive repair shops.

431 Junior member, age 25, graduate of Massachusetts Institute of Technology, desires position offering advancement, has had over two years' experience, teaching and in construction work. At present employed as assistant mechanical engineer for large hardware concern and also in cost department.

432 Position of assistant manager, chief engineer or superintendent of an industrial or power plant wanted by Junior member, having experience in engineering and experimental department of railroad, operating, erecting and laying out power plants, and general machinery in industrial works and all duties under jurisdiction of master mechanic of large chemical works.

433 Junior member, A. B. Yale, M. E. Columbia, would like to become associated with engineer or firm making specialty of design and construction of industrial plants. Experience in this line as superintendent of construction, assistant to works manager, etc.

434 Production engineer with long experience in the reduction of costs and in the introduction and operation of scientific management, wishes to get into communication with university or technical college desiring a professor in these lines.

435 Position desired with progressive manufacturing concern as executive mechanical engineer with opportunity to make savings in non-productive departments or design new additions; graduate Massachusetts Institute of Technology, American, 20 years' experience in construction, design and operation power plants and mills in various parts of United States and Canada.

436 Junior member, age 27, married, experienced in power plant erection and operation, including refrigeration experience, now employed, but desires to locate with a reliable concern with opportunity to advance. Can furnish the best of references of character, ability, etc.

437 Junior, technical education, three years' experience in gas and electric business, and two years in charge of engineering laboratory; desires change of position. Available July 1.

438 Designing engineer, nine years' experience, thoroughly familiar with design of cranes and hoisting equipment; at present employed as assistant chief draftsman by large crane builder; desires position of greater responsibility; such as complete charge of designing department of small growing firm. Location west or middle west preferred.

439 Position desired with a manufacturing company as superintendent of maintenance or industrial engineer. Eleven years' practical and technical experience in designing and constructing of machinery, jigs, tools, safety appliances, transmission, steel mill, and reinforced concrete buildings; equipments, heating and ventilating, estimating costs, writing specifications and contracts, drafting and supervision. Is accustomed to handling men. Can furnish references. Age 29, married. Location middle west.

440 Member with broad experience in construction and operation of power plants, shop experience and capable of handling any problem in design and construction that is met in water or light plants. At present employed as chief engineer of power for large mining company. Would prefer position in south or west or in Spanish or English speaking foreign country.

441 Works manager, long experience on light manufacturing, involving interchangeable parts. Competent to organize all departments of manufacturing plant along modern lines.

442 Technical graduate. Junior member. Ten years' experience in the shop and drafting room on automatic machinery, specializing on jigs and fixtures for

the manufacture of duplicate parts. Now superintendent of small manufacturing concern, desires position in larger growing organization as assistant to manager or superintendent.

443 Mechanical engineer and draftsman. Best of references.

444 Position as manager desired, by technical graduate; experience as machinist, draftsman, production and industrial engineering, installation, shop and cost systems, rearranging, equipping and layout of plants and electrical installations. Age 32. Now superintendent of factory employing 150 to 200 men.

445 Mechanical engineer, wide experience designing, building and installing machinery. Familiar with hoisting, conveying and electrical machinery, bakery and flour handling, automobile building and special machinery. Have always "made good." Desires position where varied experience will be valuable, either in engineering office or manufacturing plant. Age 40. Accustomed to executive positions.

ACCESSIONS TO THE LIBRARY

WITH COMMENTS BY THE LIBRARIAN

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

AMERICAN INSTITUTE OF ARCHITECTS. Proceedings 45th annual convention, 1911. *Washington, 1912.* Gift of the institute.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION. Proceedings of the 21st annual convention. *Chicago, 1911.* Gift of the association.

ANUARIO ESTADISTICO DE LA REPUBLICA ORIENTAL DEL URUGUAY, 1907-1908. Vol. 2, Pt. 1. *Montevideo, 1911.* Gift of Republica Oriental del Uruguay.

APPLIED METHODS OF SCIENTIFIC MANAGEMENT, F. A. Parkhurst. *New York, Wiley & Sons, 1912.*

This work is an amplification of the author's articles in Industrial Engineering and deals, not with the theoretical side of the subject, but with the details of its practical application. The work is well illustrated, many forms being given.

EIN BESUCH IM DEUTSCHEN MUSEUM ABTEILUNG II, ZWEIBRÜCKENSTRASSE, K. Matschoss. Sonderabdrick aus der Zeitschrift des Vereins Deutscher Ingenieure, 1909. Gift of Wm. Paul Gerhard.

CENTRIFUGAL PUMPING MACHINERY. The theory and practice of centrifugal and turbine pumps, C. G. de Laval. *New York, McGraw-Hill Book Co., 1912.*

Based on practical experience in the design, construction and installation of pumping machinery of centrifugal type, and confines itself to material which has been used in the actual practice of the author with Henry R. Worthington.

COAL SMOKE ABATEMENT SOCIETY. Papers read before the Smoke Abatement Conferences March 26, 27, 28, 1912. *Westminster, 1912.* Gift of the society.

CONNECTICUT BUREAU OF LABOR STATISTICS. Bulletin, 1911. *Hartford, 1911.*

DIE DAMPFKESSEL NEBST IHREN ZUBEHÖRTEILEN UND HILFSEINRICHTUNGEN, R. Spalckhaver und Fr. Schneiders. *Berlin, 1911.*

DEUTSCHES MUSEUM LEBENSBESCHREIBUNGEN UND URKUNDEN, George von Reichenbach, Walther v. Dyck. *München, 1912.* Gift of the author.

DEUTSCHES MUSEUM VON MEISTERWERKEN DER NATURWISSENSCHAFT UND TECHNIK. Führer durch die Sammlungen. *Leipzig.* Gift of Wm. Paul Gerhard.

DRIVER-HARRIS WIRE COMPANY. Properties of Round and Fattened "Nichrome" Wire. *1911.* Gift of the company.

EARNING POWER OF CHEMISTRY, Arthur D. Little. Professional Paper no. 5. Contributions to Engineering Chemistry by members of the staff of Arthur D. Little, Inc. *Boston, 1911.* Gift of Arthur D. Little, Inc.

EINRICHTUNG UND BETRIEB EINES GASWERKES, A. Schäfer. *München-Berlin, 1910.*

ELECTRIFICATION OF RAILWAYS, George Westinghouse. Gift of Westinghouse Electric & Manufacturing Co.

ELEMENTS OF STATISTICAL METHOD, W. I. King. *New York, Macmillan Co., 1912.*

Treats of the technical processes involved in the work of the statistician in the collection, compilation and interpretation of statistical data. The first work of the kind.

DER FABRIKBETRIEB, Albert Ballewski and C. M. Lewis. Ed. 3. *Berlin, 1912.*

FORSCHERARBEITEN AUS DEM GEBIETE DES EISENBETONS. Nos. 1-10, 12-17, 19. *Wien-Berlin, 1904-1912.*

HANDBUCH DER MATERIALIENKUNDE FÜR DEN MASCHINENBAU, A. Martens. Pt. 2. Die technisch wichtigen Eigenschaften der Metalle und Legierungen, E. Heyn. *Berlin, 1912.*

INTRODUCTION TO ANALYTICAL MECHANICS, Alexander Ziwet and Peter Field. *New York, Macmillan Co., 1912.*

A text book for junior and senior students based largely on the senior author's Theoretical Mechanics. The authors are professors in the University of Michigan.

KRAN UND TRANSPORTANLAGEN FÜR HÜTTEN, HAFEN, WERFT UND WERKSTATT BETRIEBE, C. Michenfelder. *Berlin, 1912.* Gift of Hunt Memorial Fund.

LABORATORY MANUAL FOR THE USE OF STUDENTS IN TESTING MATERIALS OF CONSTRUCTION, L. A. Waterbury. *New York, Wiley & Sons, 1912.*

Intended as a manual for use in schools where all testing is given in one course.

LEHRBUCH DER EISEN UND STAHLGIESSEREI, Bernhard Osann. *Leipzig, 1912.*

LOUISVILLE WATER COMPANY. Annual Report, 54th. *Louisville, 1911.* Gift of Theo. A. Leisen.

LE MECHANICHE, Guido Uvalde. *1581.*

DIE METALL UND EISENGIESSEREI MIT BESONDERER BERÜCKSICHTIGUNG DER LEGIERUNGEN UND GATTIERUNGEN FÜR DEN MASCHINENBAU, Hugo Wachenfeld. *Halle a. S., 1911.*

MILWAUKEE BUREAU OF ECONOMY AND EFFICIENCY. Bulletin, 17, 19. *Milwaukee, 1912.*

MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK. Constitution, By-Laws, List of Members and Annual Report, 1911. *New York, 1911.*

MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK. Proceedings, 1911. *New York, 1911.* Gift of Municipal Engineers of the City of New York.

NEW YORK CENTRAL AND HUDSON RIVER RAILROAD COMPANY. Annual Report of the Board of Directors to the Stockholders, 43d, 1911. *New York, 1911.* Gift of the company.

NEW YORK CITY BOARD OF WATER SUPPLY. Contract 72, 112, 113, 114. *1912.* Gift of Board of Water Supply.

ÖLMOTOREN IN VIERTAKT-UND ZWEITAKTBAUART, H. Haeder. Vols. 1-2. *Wiesbaden, 1912.*

ORGANISATION ET DIRECTION DES USINES, André Mayer. *Paris, 1911.*

POLHEM, CHRISTOPHER. MINNESSKRIFT UTGIFVEN AF SVENSKA TEKNOLOGFÖRENINGEN. *Stockholm, 1911.* Gift of Svenska Teknologföreningen.

PRACTICAL TREATISE ON LOCOMOTIVE ENGINES UPON RAILWAYS, F. M. G. de Pambour. *Philadelphia, 1836.*

The first book on the locomotive printed in America.

REALITÄTEN, ABSTRAKTIONEN, FINGIERUNGEN UND FIKTIONEN IN DER THEORETISCHEN MECHANIK VON O. E. WESTIN. *Stockholm, 1911.* Gift of Svenska Teknologföreningen.

SCIENTIFIC AMERICAN CYCLOPEDIA OF FORMULAS, A. A. Hopkins. *New York, 1911.*

SPRINGFIELD, MASS., BOARD OF WATER COMMISSIONERS. Annual Report, 38th, 1911. *Springfield, 1912.* Gift of the board.

THE TEACHING OF PHYSICS FOR PURPOSES OF GENERAL EDUCATION, C. R. Mann. *New York, Macmillan Co., 1912.*

Edited by President Butler of Columbia. The work is not, as might be supposed, an outline of courses or laboratory manual, but a discussion of the principles underlying the teaching for purposes of general culture. There are quite extensive bibliographies appended to several of the chapters, and a satisfactory index.

WÄRMETHEORIE UND IHRE BEZIEHUNGEN ZUR TECHNIK UND PHYSIK, Wegner von Dallwitz. *Berlin, 1912.*

UBER WÄRMEÜBERGANG AUF RUHIGE ODER BEWEGTE LUFT SOWIE LÜFTUNG UND KÜHLUNG ELEKTRISCHER MASCHINEN, Ludwig Binder. *Halle a. S., 1911.*

WEBB'S ACADEMY AND HOME FOR SHIPBUILDERS. Annual Report, 1911. *New York, 1911.* Gift of the academy.

UNITED ENGINEERING SOCIETY

GUIDE TO THE TECHNOLOGICAL MUSEUM, Sydney, N. S. W. *Sydney, 1910.* Gift of the museum.

ILLUMINATION OF PEOPLE'S GAS BUILDING, CHICAGO. A paper by Chas. A. Luther, read before the Illinois Gas Association March 20, 1912. Gift of People's Gas Light & Coke Co.

KAISERLICHE MARINE DEUTSCHE SEEWARTE. Jahresbericht über die Tätigkeit der Deutschen Seewarte. 33, 34, 1910-1911. *Hamburg, 1911-1912.* Gift of Annalen der Hydrographie.

PRESENT STATE OF THE EUCALYPTUS OIL INDUSTRY, Henry G. Smith. *1911.* Gift of the author.

TRUTH ABOUT MR. ROCKEFELLER AND THE MERRITTS, *F. T. Gates.* Gift of the author.

VITRIFIED BRICK PAVEMENTS FOR CITY STREETS AND COUNTRY HIGHWAYS. Gift of National Paving Brick Manufacturers' Association.

EXCHANGES

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CANADIAN SOCIETY OF CIVIL ENGINEERS. Charter, By-Laws and List of Members, 1912. *Montreal, 1912.*

INSTITUTION OF CIVIL ENGINEERS. Minutes of Proceedings, vol. 187. *London, 1912.*

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS. Transactions, vol. 19, 1911. *New York, 1911.*

TRADE CATALOGUES

W. O. AMSER, *Pittsburgh, Pa.* Gas producers with cost and operation, 34 pp.

HARDIE-TYNES CO., *Birmingham, Ala.* Heavy duty Corliss engine. 32 pp.

MCEWEN BROS., *Wellsville, N. Y.* Pumps for steam turbine drive, 10 pp.

PAWLING & HARNISCHFEGER CO., *Milwaukee, Wis.* Cutting the cost of lumber production, 63 pp.

WESTINGHOUSE MACHINE CO., *East Pittsburgh, Pa.* Turbo-alternators, 39 pp.

WM. WHARTON, JR., & CO., *Philadelphia, Pa.* Cat. 12. Manganese steel and records of Wharton manganese steel track work, 300 pp.

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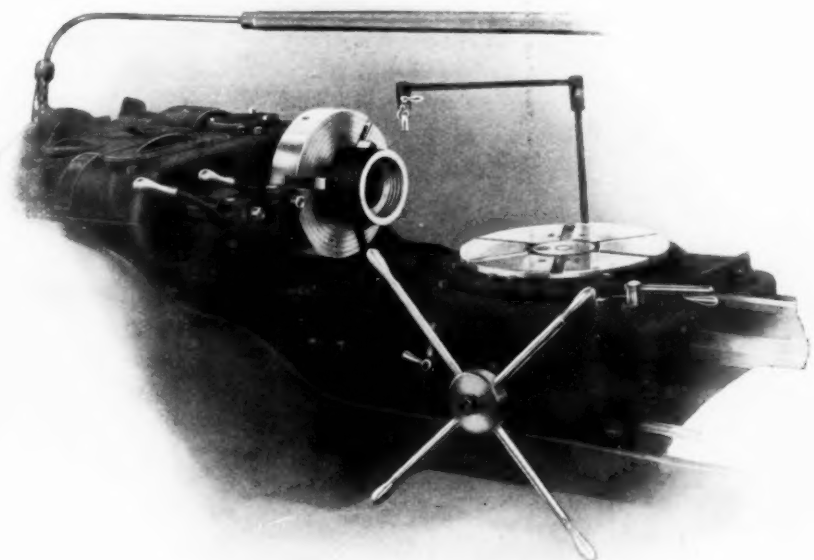

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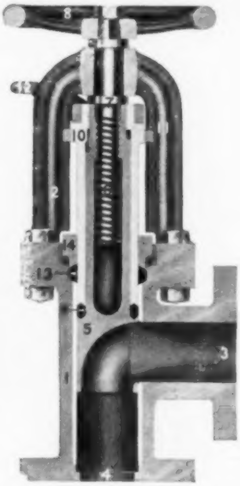

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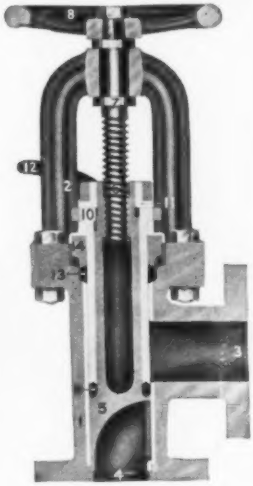

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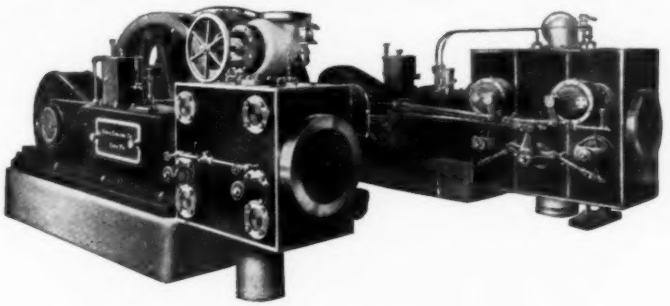

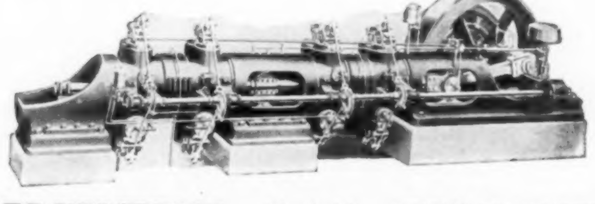

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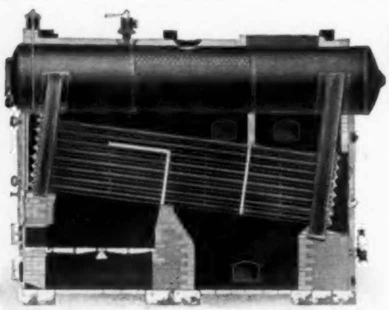

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Manufacturers of Grinding Machines. Internal Grinders, Cylinder Grinders, Surface Grinders, Drill Grinders.

GRINDING MACHINES

STEAM ENGINES AND BOILERS

AIR COMPRESSORS AIR TOOLS AND HOISTS

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Air Compressors, twenty standard types, capacity 8 to 8000 cu. ft. per minute; "Crown" and "Imperial" Air Hammers and Drills, all sizes; "Imperial" Air Motor Hoists, capacity $\frac{1}{2}$ to 5 tons.

TURRET LATHES

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SPRINGFIELD, VT.

Manufacturers of the Hartness Flat Turret Lathe; made in two sizes for both bar and chuck work.

HEAVY DUTY BORING MILLS

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Vertical Turret Machines, 28″ and 34″. Vertical Boring and Turning Machines, 42″ to 84″, inclusive.

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THE R. K. LE BLOND MACHINE TOOL CO.

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We manufacture a complete line of Heavy Duty Lathes and Milling Machines. They are scientifically designed, so the power is limited only by the strength of the cutting tool. It will pay you to investigate our machines. Catalogue upon request.

MACHINE TOOLS ENGINEERING SPECIALTIES

MANNING, MAXWELL & MOORE, Inc.

SINGER BUILDING, NEW YORK

Are the largest and best known distributors of Machine Tools in the world and carry in stock the product of the foremost designers of the many branches of machine tool building in the United States.

METAL SHOP AND FACTORY EQUIPMENT

MANUFACTURING EQUIPMENT & ENGINEERING CO.

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We manufacture a full line of all metal Shop and Factory Equipment, Sanitary Wash Bowls, Improved Soda Kettles, Improved Stools, Work Benches, Stock Racks, Sanitary Drinking Fountains, etc.

PINIONS AND GEARS

THE NEW PROCESS RAW HIDE CO.

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Manufacturers of New Process Noiseless Pinions and also of accurately cut Metal Gears of all kinds.

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WALTHAM MACHINE WORKS

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Our Bench Lathes swing 8″, will take $\frac{3}{8}$″ rod through the chuck and the workmanship is of the highest watch machine standard. It is a necessity in the modern tool room. Catalog for those interested. Also makers of Automatic Precision Bench Machinery.

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STEAM BOILERS AND ENGINES FEED-WATER HEATERS

ERIE CITY IRON WORKS

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Boilers: water tube, horizontal tubular, return tubular, water bottom portable, open bottom portable, vertical tubular and vertical water tube. Engines: Erie City "Lentz," four valve, enclosed high speed, automatic, center crank, side crank, portable and Feed-Water Heaters from 25 to 600 h.p.

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HARRISBURG, PA.

Manufacturers of Fleming-Harrisburg Horizontal Engines, Corliss and Single Valve, Simple, Tandem and Cross Compound.

STEAM ENGINES

HEWES & PHILLIPS IRON WORKS

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Makers of improved Patent, Double Port Corliss Engines, Heavy Duty or Girder Frame, Simple or Compound, having our new Franklin High-speed Liberating Valve Gear.

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THE HOOVEN, OWENS, RENTSCHLER CO.

HAMILTON, OHIO

Manufacturers of Hamilton Corliss Engines, Hamilton High Speed Corliss Engines, Hamilton Holzwarth Steam Turbines, Special Heavy Castings.

BOILERS

E. KEELER COMPANY

WILLIAMSPORT, PA.

Water Tube, Internal Furnace and Return Tubular Boilers. Self-Supporting Stacks, Feed Water Heaters.

BOILERS

KINGSFORD FOUNDRY & MACHINE WORKS

OSWEGO, NEW YORK

Scotch Boilers, Dry and Waterback; also Improved Manning Vertical Boilers, and Special Boilers for Steam Heating.

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MESTA MACHINE CO.

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Complete Power Plant Equipment; Gas and Steam Engines; Condensers; Air Compressors; Power Transmission Machinery.

STEAM ENGINES

PROVIDENCE ENGINEERING WORKS

PROVIDENCE, R. I.

Rice & Sargent Corliss Engines, Improved Greene Engines and Repair Parts, Special Machinery.

GAS ENGINES AND GAS PRODUCERS

POWER PLANT AUXILIARIES AND SPECIALTIES

AIR COMPRESSORS AIR TOOLS AND HOISTS

INGERSOLL-RAND COMPANY

11 Broadway NEW YORK

Air Compressors, twenty standard types, capacity 8 to 8000 cu. ft. per minute; "Crown" and "Imperial" Air Hammers and Drills, all sizes; "Imperial" Air Motor Hoists, capacity ½ to 5 tons.

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JENKINS BROS.

NEW YORK BOSTON PHILADELPHIA CHICAGO

Manufacturers of the genuine Jenkins Bros. Valves, Jenkins Discs, Jenkins '96 Packing, Jenkins Bros. Pump Valves, Jenkins Gasket Tubing. Sole agents for Sellers' Restarting Injector. Catalog mailed on request.

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Telephone: 6097 Franklin

Heat and Cold Insulating Materials. Headquarters for 85% Magnesia Asbestos and Brine Pipe Coverings, Asbestos Products, etc.

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Manufacturers of Valves for various purposes and pressures; Hydrants; Indicator Valves for Automatic Sprinkler Equipment.

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THE LUDLOW VALVE MFG. CO.

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Manufacturers of genuine Ludlow Gate Valves for all purposes. Special Blow-off Valves. Check Valves. Foot Valves. Sluice Gates. Indicator Posts. Fire Hydrants.

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Manufacturers of high-grade engineering specialties, comprising Brass and Iron Valves Whistles, Cocks, Gauges, Injectors, Lubricators Oil Pumps, Oil and Grease Cups, etc., adapted to the requirements of all classes of machinery.

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Manufacturers of Bronze and Iron Bodied Valves for various pressures and purposes.

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MOREHEAD MANUFACTURING CO.

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Return, Non-Return Vacuum and Condenser Steam Traps. The Morehead Tilting Steam Trap is the original design of *tilting* trap, having been on the market for a quarter of a century. For reliable and satisfactory service this type of trap recommends itself. Illustrated descriptive catalog sent on request.

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C. J. TAGLIABUE MFG. CO.

396–398 BROADWAY NEW YORK, N. Y.

Local Sales Offices in Chicago and San Francisco

Manufacturers of Instruments for Indicating, Recording and Controlling Temperature and Pressure. Thermometers; Automatic Controllers; Gages; Oil Testing Instruments; Engineers' Testing Sets, Pyrometers, Barometers, Hygrometers, Hydrometers, etc.

See our Condensed Catalogue in April 1911 number of The Journal.

LUBRICATING OILS

THE TEXAS COMPANY

NEW YORK HOUSTON

Lubricating Oils for Power Plants, Central Stations, Machine Shops, Foundries and all general purposes. All classes of Petroleum Products of the highest quality.

CONDENSERS PUMPS COOLING TOWERS

WHEELER CONDENSER & ENG. CO.

MAIN OFFICE AND WORKS: CARTERET, N. J.

Surface, Jet and Barometric Condensers, Combined Surface Condensers and Feed Water Heaters, Cooling Towers, Edwards Air Pumps, Centrifugal Pumps, Rotative Dry Vacuum Pumps and Multiple Effect and Evaporating Machinery.

CONDENSERS COOLING TOWERS FEED-WATER HEATERS

C. H. WHEELER MFG. CO.

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NEW YORK BOSTON CHICAGO SAN FRANCISCO

Manufacturers of High Vacuum Apparatus, Condensers, Air Pumps, Feed-Water Heaters, Water Cooling Towers, Boiler Feed and Pressure Pumps.

PUMPS AND HYDRAULIC TURBINES

HYDRAULIC TURBINES PUMPING MACHINERY

ALLIS-CHALMERS COMPANY

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Builders of Reaction and Impulse Turbines, in capacities up to 20,000 H.P. High Duty Pumping Engines, Centrifugal Pumps, Single and Multi-Stage; Screw Pumps, Elevator Pumps, Geared Pumps, Mine Pumps and Electrically Driven Pumps. Hydraulic Transmission Pumping Machinery.

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Manufacturers of Marsh and American Steam and Power Pumping Machinery. The valve motion is designed for efficient and reliable service, which, combined with low maintenance cost, should appeal to engineers who desire to reduce their operating expenses. Literature upon request.

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M. T. DAVIDSON CO.

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NEW YORK: 154 Nassau St. BOSTON: 30 Oliver St.

High grade economical Pumps for all services. Surface and Jet Condensers.

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HOISTING AND CONVEYING MACHINERY

HOISTING ENGINES
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Hoisting Engines—steam and electric, for every use of the contractor, miner, warehouseman, railroads, shipowners, etc. Derricks, Derrick Irons and Derrick Hoists, Cableways for hoisting and conveying, Marine Transfer for coal and cargo handling.

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PHILADELPHIA CHICAGO INDIANAPOLIS

Elevators and Conveyors for every purpose; all accessories; Power Transmission Machinery.

ELEVATING AND CONVEYING MACHINERY

MEAD-MORRISON MANUFACTURING CO.

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Coal-Handling Machinery, Hoisting Engines, complete Discharging and Storage Plants Cable Railways, Marine Elevators, McCaslin and Harrison Conveyors, Steam, Electric, Belt and Gasoline Hoists, Derrick Swingers, Grab Buckets, Steam Boilers, Locomotive Derricks, Suspension Cableways.

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THE MORGAN ENGINEERING CO.

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Are the largest builders of Electric Traveling Cranes in the world. We also design and build Steel Plants complete, Hammers, Presses, Shears, Charging Machines and all kinds of Rolling Mill and Special Machinery.

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Manufacturers of all types of Passenger and Freight Elevators.

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ROBINS CONVEYING BELT COMPANY

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The Robins Belt Conveyor was the original and is today the standard of this type of conveying machinery. It is successfully and economically conveying ore, rock, coal and similar materials under the most trying conditions of service. Correspondence invited.

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JOHN A. ROEBLING'S SONS COMPANY

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Manufacturers of Iron, Steel and Copper Wire Rope, and Wire of every description.

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Electric Travelers for all purposes. Gantries. Wharf Cranes. Railroad Wrecking Cranes. Mono-Rail Systems. Electric Motor Controllers.

THE TOLEDO BRIDGE & CRANE CO.

TOLEDO, OHIO

Toledo Cranes and Hoists; Coal and Ore Handling Bridges; Grab Bucket Machinery; Electric and Hand Power Cranes, all types, any capacity; Structural Steel for Factory Buildings.

CRANES
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THE WEBSTER M'F'G COMPANY

(Successors to WEBSTER M'F'G CO.)

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Manufacturers of Elevating, Conveying and Power Transmitting Machinery for all purposes. Over thirty years' experience in this line and extensive facilities for manufacturing give us large advantages. Belt Conveyors for handling cements, ores, sand, gravel, etc. Coal and Ash Handling Systems for power plants and buildings. Chain belting. Gearing.

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POWER
TRANSMITTING
MACHINERY

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Makers of the Triplex Block and Electric Hoists. The Triplex Block is made in 14 sizes, with a lifting capacity of from ¼ to 20 tons; Electric Hoist in 10 sizes, ¼ to 16 tons.

CHAIN
BLOCKS
ELECTRIC
HOISTS

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Builders of Electrical Machinery of every description; Motors and Generators for alternating and direct current; Rotary Converters, Transformers, Switchboards.

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SCHENECTADY, N. Y.

Generators, motors, Curtis steam turbines, switchboards, transformers, locomotives, lighting equipments, air compressors, electrically heated devices for industrial purposes. Largest manufacturer of electrical apparatus in the world.

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WAGNER ELECTRIC MFG. COMPANY

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Producers of the commercially successful Single-phase Motor. Pioneers in Power and Lighting Transformers. Builders of the most liberally designed and rugged polyphase generators and motors the market affords. Manufacturers of the most comprehensive line of switchboard and portable instruments offered to-day.

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WESTINGHOUSE ELECTRIC & MFG. CO.

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Westinghouse Electric Motor Drive. Pumps, compressors, hoists, machine tools and every class of apparatus develop their highest efficiency when individually driven with Westinghouse Motors.

ELECTRIC
MOTOR
DRIVE

AIR COMPRESSORS AND PNEUMATIC TOOLS

AIR COMPRESSORS
PNEUMATIC TOOLS

AIR COMPRESSORS
TOOLS
HOISTS AND SAND RAMMERS

FOUNDRY EQUIPMENT

SAND RAMMERS
AIR TOOLS AND HOISTS
COMPRESSORS

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BLOWERS, FANS, DRYERS, ETC.

ROLLING MILL MACHINERY

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ALUMINUM COMPANY OF AMERICA

PITTSBURGH, PA.

Aluminum Ingot, Sheet, Rod, Wire, Cable, Tubing and other forms.

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AUBURN BALL BEARING COMPANY

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Auburn Four Point Contact Cone Principle Ball Thrust Bearings, Auburn Steel, Brass and Bronze Balls, Solid and Hollow.

CASTINGS MACHINE WORK GRINDING MACHINES

BUILDERS IRON FOUNDRY

PROVIDENCE, R. I.

Engineers, Founders and Machinists

Castings of Unusual Size, Weight and Strength. Large and Accurate Machine Work. Grinding and Polishing Machines.

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ROBERTS FILTER MFG. CO., Inc.

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Designers and Builders of Water Filters of both the Pressure and Gravity types, of any capacity.

BALL AND ROLLER BEARINGS

STANDARD ROLLER BEARING COMPANY

50th St. and Lancaster Ave. PHILADELPHIA, PA.

Largest manufacturers in the world of Ball and Roller Bearings for all purposes. Steel, Bronze and Brass Balls.

BRIGHT COLD FINISHED STEEL BARS

UNION DRAWN STEEL CO.

BEAVER FALLS, PA.

Makers of Bright Cold Finished Bessemer, Open Hearth Crucible and Alloy Steels, in Rounds, Flats, Squares, Hexagons and Special Shapes.

PLANERS

S. A. WOODS MACHINE CO.

BOSTON

CHICAGO-NORFOLK
NEW ORLEANS-SEATTLE

The Planer Specialists — Planers for Dressing Lumber

CONDENSED CATALOGUES

OF

MECHANICAL EQUIPMENT

SECTION ONE (PART TWO)

Power Plant Equipment

Other sections of the Condensed Catalogues to be published in subsequent issues of The Journal during 1912 will include Hoisting, Elevating and Conveying Machinery, Industrial Railway Equipment, Power Transmission Machinery, Electrical Equipment, Metal Working Machinery, Machine Shop and Foundry Equipment, Steel and Rolling Mill Equipment, Pumping Machinery, Mining and Metallurgical Equipment, Heating and Ventilating Apparatus, Refrigerating Machinery, Air Compressors and Pneumatic Tools, Engineering Miscellany.

At the close of the year the entire collection of Condensed Catalogues will be reprinted in volume form and distributed to members without charge.

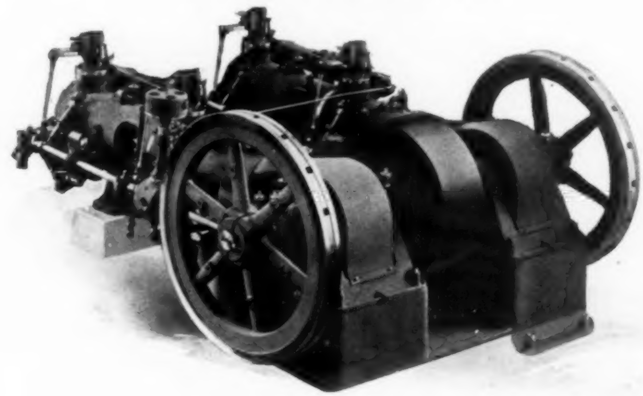
THE AMERICAN SOCIETY *of*
MECHANICAL ENGINEERS

THE ELYRIA GAS POWER CO.

ELYRIA, OHIO

GAS ENGINES

Builders of "The Little Big Engine"



FEATURES OF "THE LITTLE BIG ENGINE"

Uses Producer, Natural and City Gas, Gasoline and Distillate.

Only change necessary in change of fuel is length of connecting rod for altering compression and exchange of fuel handling devices.

Economy ranges from 10,000 to 12,000 BTU, depending on size.

All sizes with water-cooled exhaust valves; all but No. 2 have water-cooled pistons and piston rod. No water joints subject to explosion pressures.

Governs by varying lift of inlet valves. Good regulation.

Pulley or flexible coupling bolted to flywheel, either side.

Ignition make-and-break or jump spark, both for continuous service.

Our "Show-me" guarantee means much to the buyer. Get it.

Crank Shaft half of cylinder bores. Main bearings removable bushings.

Automatic Air Starting Equipment always included.

Gas Producers and Dynamos furnished. Quick delivery a feature.

Engineers can safely use for estimate figures $80 per H. P. in smallest to $60 per H.P. in largest sizes. This includes engine and anthracite producer, delivered and fully installed above foundations.

We deal with purchasers or Engineers only. We have no Agents.

APPROXIMATE RATINGS AND FLOOR SPACE

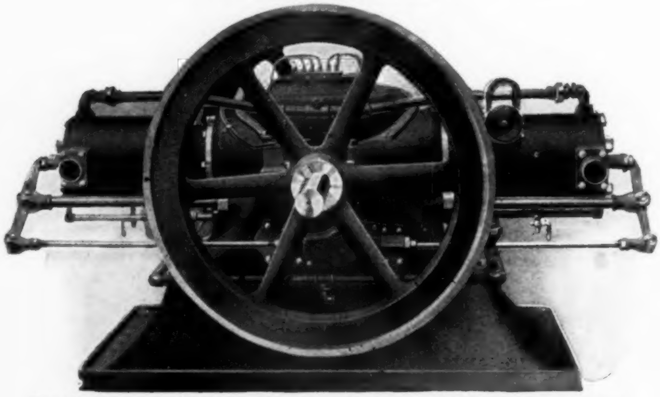
Fuel	Compression	Engine No. 2		Engine No. 3		We twin the No. 4 and No. 5 — Engine No. 4 (When twinned, double rating, same speeds.)		Engine No. 5	
		H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.
Natural Gas.....	140 lbs.	40 30	325 250	60 45	290 220	75 60	275 225	110 85	260 200
City Gas........	125 lbs.	40 30	325 250	60 45	290 220	75 60	275 225	110 85	260 200
Gasoline or Distillate..........	75 lbs. to 100 lbs.	35 30	325 275	55 45	290 240	70 60	275 235	100 85	260 220
Gasoline or Distillate with Water	100 lbs. to 125 lbs.	40	325	65	290	80	275	120	260
Producer Gas....	160 lbs. to 180 lbs.	30 25	325 275	45	290	55	275	85	260
Over all space		5′-0″x10′-0″		11′-6″x5′-7″		12′-6″x6′-0″ Twinned 12′-6″x11′-6″		14′-0″x6′-10″ Twinned 14′-0″x13′-6″	

THE HEER ENGINE COMPANY

PORTSMOUTH, OHIO

HIGH GRADE GAS AND GASOLINE ENGINES

Stationary, Portable and Traction



For all general stationary power purposes this engine is our standard type, adapted to mills, factories, workshops, mines, electric lighting plants, and in fact, any place where absolutely steady and reliable power is required.

THE HEER TWO CYLINDER OPPOSED ENGINE

When it is desired to develop power in units of from 5 to 100 H. P. the two cylinder opposed type of gas or gasoline engine gives better satisfaction at less expense for room, fuel, and attendance than any other prime mover.

The Two Cylinder Opposed requires no excess weight to hold it in place—its perfect balance and evenness of construction retains its equilibrium and requires absolutely no re-adjustment when moved to another location. In the elimination of vibration there is naturally a saving of its energy, thus developing greater power at a lesser cost.

Another very important feature and advantage of the Two Cylinder Opposed is the securing of practically two engines in one or an emergency plant in case one cylinder gets out of order or needs repairing for any cause; it can be disconnected instantly without loss of time and the engine will run indefinitely on one cylinder. This is a very valuable feature which any user of power will appreciate.

CONSTRUCTIONAL FEATURES

Four Cycle Operation conceded most economical of fuel.

Mixer or *Carburetor* a combination, if desired can be used for gas or gasoline, and changed from either fuel to the other without stopping the engine.

Fuel may be natural or manufactured gas, gasoline, California distillate, kerosene, solar oil, or Oklahoma distillate.

Ignition is Jump Spark, the simplest and most reliable.

Speed is controlled by governor and can be changed as desired.

Power and *Test*. A brake test is given each engine, and all engines are rated at less than their brake horse power.

DIMENSIONS OF STATIONARY TYPES

Size of Engine in Rated Horse Power	10 H. P.	16 H. P.	25 H. P.	40 H. P.
Bore of Cylinder	5″	6″	7″	9″
Stroke	5	6	7	10
Diameter of Crank Shaft in Pins and Bearings	2	$2\frac{3}{8}$	$2\frac{3}{4}$	4
Crank Shaft Extended on One End for Pulley	6	8	10	12
Full Length of Crank Shaft Regular	$31\frac{1}{8}$	$37\frac{1}{8}$	$43\frac{1}{8}$	$57\frac{3}{8}$
Full Length of Crank Shaft Extended both ends	$36\frac{5}{8}$	$44\frac{5}{8}$	$52\frac{5}{8}$	$68\frac{7}{8}$
Length of Base at Bottom	40	$46\frac{3}{4}$	$53\frac{1}{2}$	66
Width of Base at Bottom	20	23	26	34
Length of Engine over all	$50\frac{7}{8}$	$59\frac{7}{8}$	$68\frac{3}{4}$	$99\frac{1}{2}$
Width of Engine over all Regular	$31\frac{1}{8}$	$37\frac{1}{8}$	$43\frac{1}{8}$	$57\frac{1}{8}$
Diameter of Fly Wheels	26	$30\frac{1}{2}$	35	48
Pulley any size up to (Larger Size Extra)	14	16	24	30
Revolutions per Minute (Normal)	600	500	450	350
Total Weight of Complete Engine	800	1300	2200	5200
Style Number	20	21	22	23

Write for Catalogue.

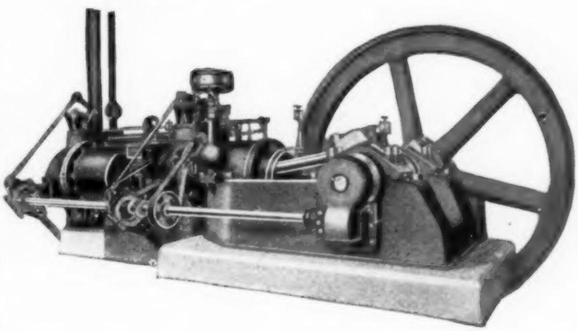
THE ST. MARYS MACHINE CO.

ST. MARYS, OHIO

OIL ENGINES AND SUCTION GAS PRODUCERS; HEAVY-DUTY TANDEM ENGINES; SINGLE-CYLINDER SOLAR OIL AND DISTILLATE ENGINES; PORTABLE ENGINES; TRACTION ENGINES. ENGINES FOR EVERY POWER PURPOSE.

HEAVY-DUTY TANDEM GAS ENGINE

Maximum Size 480 h.p.

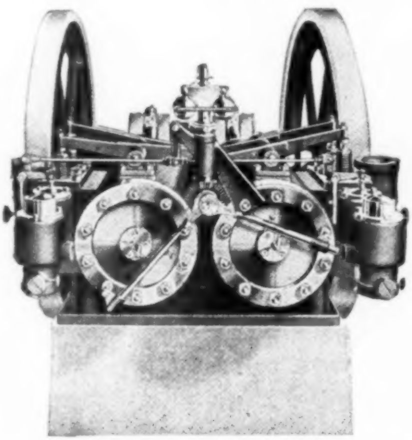


This engine operates on the four-stroke cycle. There are two cylinders arranged tandem, each having one single-acting piston. The two pistons are connected by a water-cooled piston rod, the front piston serving as a cross-head carrying the wrist pin, and but one connecting rod and crank is necessary as the pistons move together. This engine lends itself to various combinations for increasing the power of a plant.

DUPLEX SOLAR OIL ENGINES

50 h.p. up to 150 h.p.

This engine is designed for use with natural gas, city gas, gasoline, distillate, solar and crude oils, and is of the throttle-controlled type. An impulse is obtained at each revolution, resulting in greater steadiness.



The regulating device on these engines consists in vertical balanced valves which are moved by the governor and actuated by levers. The air and gas valve areas are proportioned to supply gas and air in the proper proportions to form an inflammable mixture of constant quality in any quantity that the governor may demand.

The lay shaft, igniter, eccentric, governor and pump are common to both cylinders. Each cylinder has its own regular mixing chamber attached directly to throttling chamber, doing away with long intake pipes that cause a governor to operate so sluggishly. This insures the correct amount of mixture in both cylinders, and at no time is the explosion greater in one cylinder than in the other or than the horse power required, hence a steady power.

SINGLE-CYLINDER SOLAR OIL ENGINES

10 h.p. up to 90 h.p.

These engines operate on the four-cycle plan and are designed to embody every feature calculated to insure the greatest strength and symmetrical appearance of the engine.

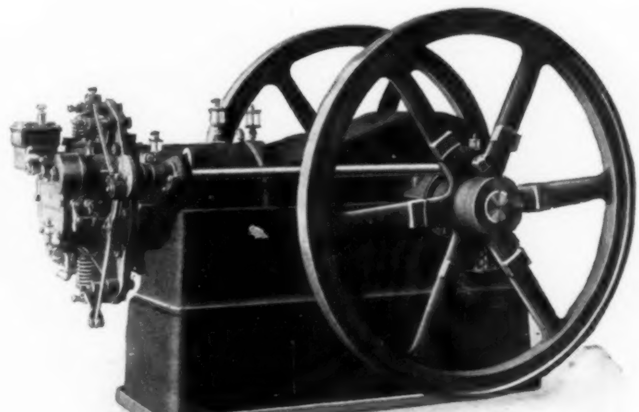
THE WISCONSIN ENGINE CO.

CORLISS, WISCONSIN

COMPLETE PLANTS

GAS OIL STEAM

ADAMS WISCONSIN GAS ENGINES. ADAMS WISCONSIN KEROSENE GAS ENGINES. WISCONSIN HIGHER SPEED CORLISS ENGINES. PRODUCERS TO FIT THE FUEL: ANTHRACITE, BITUMINOUS, LIGNITE, OIL PRODUCERS.



ADAMS-WISCONSIN KEROSENE GAS ENGINE

Capacity 50 BHP to 200 BHP. Built under Rumely patents. Gasifies and uses kerosene, gas oil, naphtha or gasoline. All these oils are gasified in a cold carburetor exactly as gasoline is gasified. 200,000 HP now in use.

WISCONSIN HIGHER SPEED CORLISS ENGINE

A heavy duty engine, built in capacities 100 HP to 12,000 HP, for all purposes. Highest efficiency for those who demand the best. Bulletin C-4 tells the details.

The Badger Engine Jack turns an engine over. Uses steam or compressed air. Get the story—Ask for Bulletin C-5.

JOHN MOHR & SONS

349-359 W. Illinois St. CHICAGO, ILL.

GARBE WATER TUBE BOILER, BLAST FURNACES, STEEL LADLES, HOT STOVES, CUPOLAS, FURNACES, MIXERS, CONVERTERS, STERILIZERS, ETC.

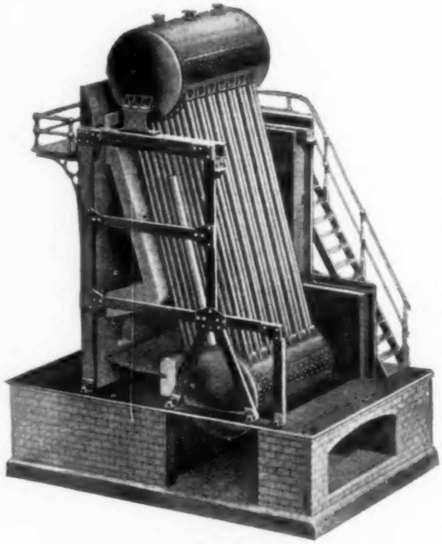
THE GARBE BOILER

Special Advantages

All handholes with their troublesome and expensive gaskets are eliminated, as the tubes are expanded into very large drums which are equipped with the patented pressed "Garbe" Plate. Any tube can easily and quickly be inserted, removed and replaced without disturbing any of the others.

Elimination of all flat surfaces, stay bolts and braces. All parts of Boiler are cylindrical and curved.

All tubes are absolutely straight and nearly vertical, therefore the entire circumference of tube is directly exposed to the gases. The effective heating surface is materially larger than that obtained by horizontal tubes.



Garbe Patent Water Tube Boiler

The upper drum is suspended from a substantial structural frame work, absolutely independent from the mason work. The lower drum is in contact with two slides or guides, thereby allowing free expansion of tubes, equalizing the strain between drums and reducing chances of leakage to a minimum.

The vertical arrangement of tubes allows the steam to develop very freely and to flow by the shortest way possible without changing direction to the upper drum, thereby causing a very rapid circulation. The tubes are distributed over the full length of the Boiler, thus giving a large and uniform steam liberating surface, equal to the full area of the tubes. This vertical arrangement of tubes will do away with local overheating and consequent rupture of the tubes so often occurring in horizontally arranged tubes.

Soot, dust and ashes cannot accumulate on tubes or any part of drum, thereby allowing longer periods of operation without the necessity of cleaning.

Large water capacity, due to the extremely large size of upper and lower drum, insuring a more constant water level than any other Boiler.

The feed water passes through the rear bank of tubes, which have the lowest temperature, to the lower drum and deposits therein all impurities.

Over half of the entire heating surface is effective in liberating steam.

Practically no scale in tubes owing to rapid circulation and vertical tubes.

Further Information on Request.

THE GAS MACHINERY CO.

CLEVELAND, OHIO, U. S. A.

COAL AND WATER GAS APPARATUS EXHAUSTERS, CONDENSERS, SCRUBBERS, TAR EXTRACTORS, WASHERS, PURIFIERS, VALVES, CONNECTIONS, BY-PRODUCT MACHINERY, COMPLETE GAS PLANTS.

GASMACO

Our business is so largely concerned with specific requirements of individual Gas Companies that a catalogue of our products is hardly feasible; but we issue a large number of Bulletins in which special features and various applications of our products are fully illustrated and described.

BULLETINS DESCRIBING THE FOLLOWING WILL BE SENT ON REQUEST

I. COAL-GAS, OIL-GAS, and CARBURETTED WATER-GAS PLANTS for illuminating or fuel purposes.

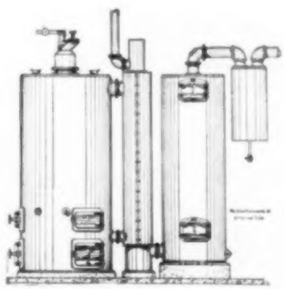
II. AMMONIA APPARATUS for making aqua-, anhydrous- or concentrated ammonia.

III. TAR STILLS.

IV. GAS VALVES "Cone Disc" all iron Double Gate Valves, Angle Valves and Gas Connections.

V. BLUE-WATER-GAS-PLANTS for welding, brazing, etc.

VI. GAS PRODUCERS for small anthracite coal, made in sizes from 35 H. P. to 300 H. P. for fuel and power purposes.



Gas Producer

VII. MUFFLE FURNACES for enameling, direct or producer-gas fired, with recuperators to save a large amount of the heat in waste gases.

VIII. BRICK KILNS, continuous tunnel kilns.

THE MODEL STOKER COMPANY

DAYTON, OHIO

THE MODEL AUTOMATIC SMOKELESS FURNACE

We manufacture exclusively the Model Automatic Smokeless Furnace. An automatic furnace for power boilers which both stokes and cleans the fire, insuring practically complete or smokeless combustion, decided economy, superior utility, durability and low cost of maintenance.

It is an advance development of the double or side feed type.

All parts are well protected against destructive heat and readily adjustable to suit requirements. Stoker engine uses only about ½ of 1% of steam made.

Any or all parts can be operated by hand. Combustion is complete in fire chamber, and there is no smoke even when heat gases pass directly from under the arch to the water surface of boiler.

The improved construction renders it the most durable and most efficient furnace in use. Requires less fuel, less labor and less cost for maintenance for any given duty. Uses successfully any soft coal of feedable size. Responds readily to any variations and will crowd a boiler quickly and strong. Adaptable to any style of boiler and to every class of duty requiring high temperatures.

Coal can be supplied by gravity or by hand and ash removed mechanically or by hand.

Improved Construction and Operation

The improvements embodied in the Model Automatic pertain to simpler and better construction, interchangeability of parts, greater durability, ready access and minimum cost for renewals, adjustability to meet varying requirements due to variations in fuel or of duty, regularity of fire, variable to suit requirements, constant automatic cleaning of fire, insuring continuous smokeless combustion, greater utility and minimum labor for attendant.

Its efficiency and general utility is admittedly unequaled by any other type or make of boiler furnace.

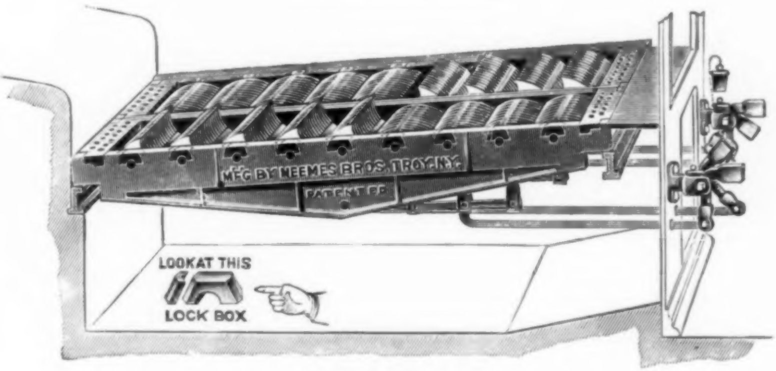
The only furnace which KEEPS the fire CLEANED.

NEEMES BROTHERS

24-30 River Street, **ESTABLISHED 1874** TROY, N. Y., U. S. A.

Babcock & Wilcox, Lmtd., Montreal, Canada. Sole makers for Canada.
The Burke Engineering Co., 525 Industrial Trust Bldg., Providence, R. I.
Sole Agents for the New England States.

MANUFACTURERS OF SQUARE AND ROUND GRATES



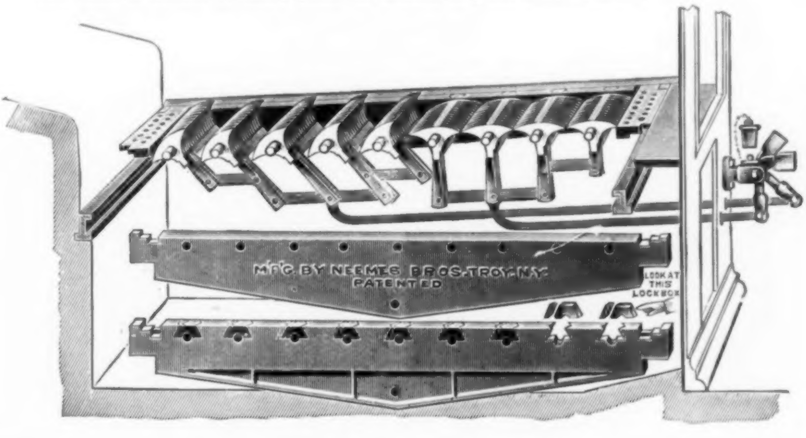
A COAL-SAVING GRATE

A grate which uses the coal wastelessly and which is so constructed that long life and continually satisfactory grate service are features.

NEEMES BROS. IMPROVED SHAKING AND DUMPING GRATE

It is a triple value grate—enables you to shake out your ashes, cut out your clinkers, or dump your fire, if necessary. This grate cuts the clinker from both sides of the shaker alike. This is the kind of a grate that is wanted today, and not one that merely shakes out a little ashes. It burns all kinds and grades of fuel, and burns it all up. The construction of the grate is strong. The teeth cannot break off, as we cut and crush the clinker in the center of the concaved teeth, and not on the points of the teeth. It is easy to operate, thoroughly dependable; it accomplishes perfect results with cheaper coal and with less coal than you are now using, thus effecting a double saving, and assures perfect combustion of any grade you may use. The Lock Box is also an important feature. When the shakers are set in the frame, and the boxes put in with the Locks, no shaker can possibly raise in the fire.

This grate is backed by many years' experience as grate manufacturers.



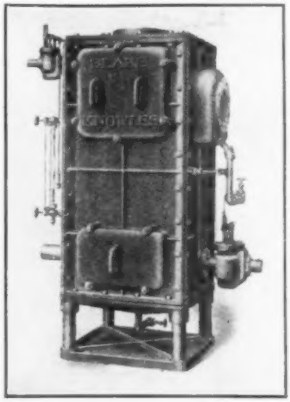
THE BLAKE & KNOWLES STEAM PUMP WORKS

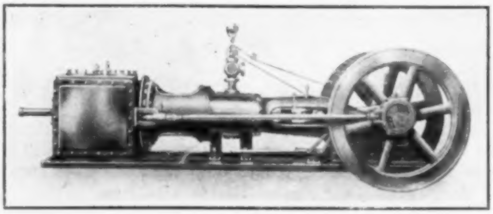
MAIN OFFICE: 115 BROADWAY, NEW YORK
FACTORY: EAST CAMBRIDGE, MASS.

FEED WATER HEATERS

Both Open and Closed Types

Sizes for all conditions of service





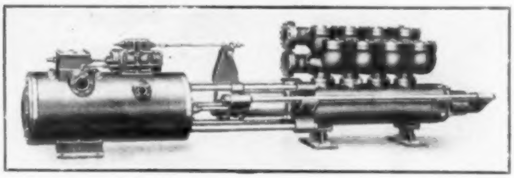
ROTATIVE DRY VACUUM PUMPS

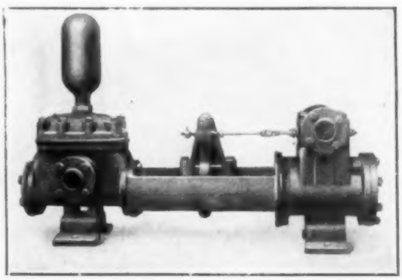
Steam and Power

For High Vacuum Service

SINGLE COMPOUND PLUNGER PUMPS

For Boiler Feeding, Elevator Service, Etc.

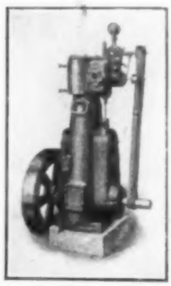




VERTICAL HIGH SPEED STEAM ENGINES

Single or Double

For Pumping or Generating Service

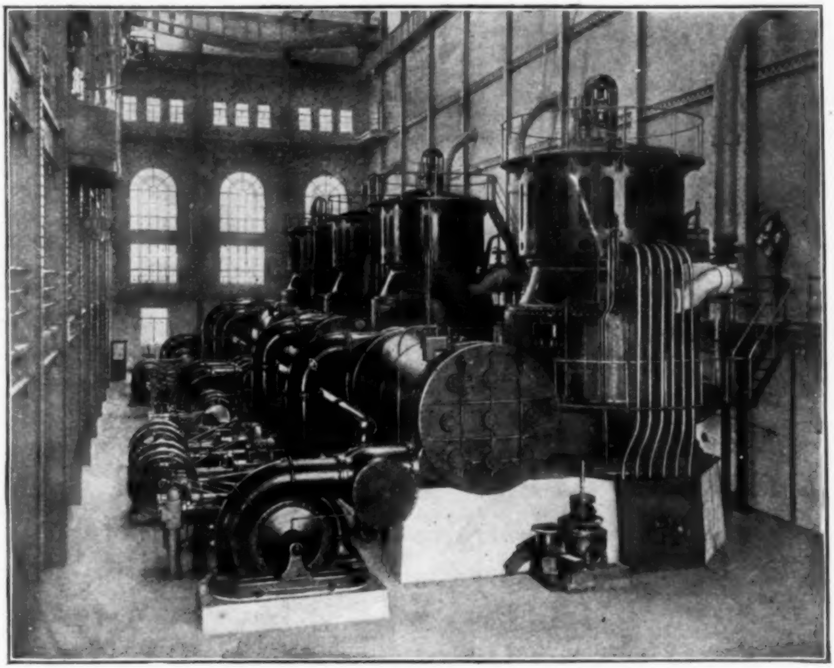


IMPROVED SIMPLEX PUMPS for Boiler Feeding, Pressure and Tank Service

HENRY R. WORTHINGTON

115 BROADWAY, NEW YORK

SURFACE, BAROMETRIC AND CENTRIFUGAL JET CONDENSING SYSTEMS, COMPLETE WITH AUXILIARIES FOR HIGH VACUUM WORK: — COOLING TOWERS, DUPLEX DIRECT-ACTING, CENTRIFUGAL, TURBINE PUMPS FOR EVERY SERVICE; BOILER FEED, ELEVATOR, FIRE, PRESSURE PUMPS; WATER METERS; WATER WORKS, SEWAGE AND DRAINAGE PUMPING ENGINES.



One of the N. Y. C. & H. R. R. Co. Power Plants

All WORTHINGTON CONDENSING APPARATUS, whether of the SURFACE or JET type, is designed upon the counter-current principle, and is capable of maintaining in service the highest vacuum attainable with the quantity and temperature of water for which it is designed.

The success of this apparatus has been due to its careful development along scientific engineering lines, in many of which the WORTHINGTON COMPANY was the Pioneer. All of the details of design are carefully worked out with reference to durability as well as efficiency and absolute reliability in service.

The WORTHINGTON COMPANY will be pleased to furnish preliminary estimates, drawings and advice at all times.

THE KENNICOTT COMPANY

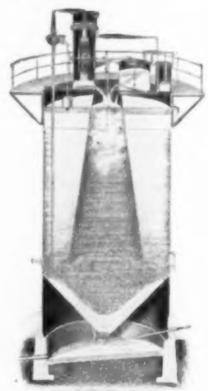
CHICAGO HEIGHTS, ILL.

Sales Office
14th Floor Corn Exchange Bank Building,
Chicago, Ill.

Eastern Office
50 Church Street,
New York, N. Y.

WATER SOFTENERS FOR THE TREATMENT OF WATER FOR BOILER FEED PURPOSES, FOR RAILROADS AND INDUSTRIAL PLANTS, FOR THE USE OF LAUNDRIES, TANNERIES, DYE WORKS, AND ANYWHERE WHERE A SOFT, CLEAR WATER IS OF ADVANTAGE.

DESCRIPTION OF OUR TYPE "K" WATER SOFTENER



The type "K" KENNICOTT WATER SOFTENER, a sectional view of the same being shown at the right of this description, represents the many years' experience which THE KENNICOTT COMPANY has had in WATER SOFTENING.

In order to have a perfect water softener it is necessary to have a machine that will automatically treat varying quantities of water with varying quantities of materials, and which will require the least possible amount of attention and soften a water at the lowest possible cost. This has been accomplished in our type "K" machine.

This machine is continuous in its action, automatically starting and stopping with the beginning and ceasing of the flow of the water into the softener. The water is pumped but once into the softener, and it is delivered at the top. The water as it flows into the softener furnishes all the power the apparatus requires, both for mixing the chemical reagents of the water to be purified as well as for operating automatically all the mechanism of the apparatus. One great particular advantage of this machine is that the parts *REGULATING* the feed of chemicals do not come in contact with the chemicals and, therefore, cannot be subject to stoppage and cannot in any way be affected by the chemicals.

The conical down-take in the softener, and thorough mixing which the water receives in the top of the down-take is of the greatest possible advantage in reaction and sedimentation. By the above means the water becomes quiet as quickly as possible after being thoroughly mixed with the chemicals. The softeners are designed so that the rate of flow in inches per hour is low and sedimentation, therefore, takes place very rapidly.

The softeners are designed to be either top operated, where it is necessary to economize on ground space, or all the chemical mixing and feeding tanks can be located on the ground.

Many machines of both types can be seen in operation and have been in operation for several years.

This type "K" softener has been built in every size from 150,000 gallons of water per hour to 500 gallons of water per hour. The largest CONTINUOUS STEEL TANK SOFTENER in the world having been built and installed by THE KENNICOTT COMPANY. All our experience has been directed towards building a machine which is guaranteed to produce uniform results and WE HAVE MADE GOOD.

We publish a full description of the operation of this type "K" softener which gives detailed information and also gives photographs of many of the softeners which have been installed for some of the best known firms and railroads in this country and abroad. They cover almost every line of business. The matter referred to will be mailed you upon request.

WATERS GOVERNOR COMPANY

1122 Oliver Bldg., BOSTON, MASS.

REDUCING VALVES AND ENGINE GOVERNORS

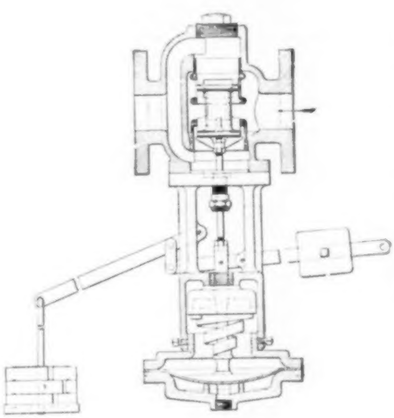
ENGINE GOVERNORS

These Governors are suitable for every variety of stationary and portable steam engine. They have adjustable speed regulation, automatic safety stop, Sawyer's lever, solid composition valves and seats, and all parts interchangeable.

The Waters Governors have been in use over forty years and have steadily grown in favor since their introduction. The design is such that they are not affected by the action of gravity, the weight remaining always in the same plane. The valve is of large area, greatly in excess of the steam pipe, and being quick acting and sensitive, insures economical results as well as close regulation. The valves are evenly balanced and have large openings with small travel.

Catalog on Request.

REDUCING VALVES



The accompanying illustration shows our Improved Reducing Valve. The "simplicity" of its construction can readily be seen and appreciated, while its "accessibility" can also be noted at a glance.

Diaphragm is connected by a ½ inch pipe with the low pressure side, and the pressure in the diaphragm chamber, working against the spring, tends to close the valve, spring opening the valve when the pressure falls. A wide range of reduced pressures can be easily and quickly obtained. Particularly desirable for steam heating purposes. The square weight, fastened with a set screw, is simply a counterweight, to be moved in or out as the case may be, to obtain any pressure in between any two weights placed on the scale pan. These valves require no head room, hanging below the line of piping, and can be removed downward, leaving valve chamber only in line of pipe.

We wish to emphasize the fact that with Waters Valves it is not necessary to buy a special valve with outlet larger than inlet, at increased cost. With our valves an enlarged outlet flange answers exactly the same purpose, because the control to operate our valve is taken outside the valve itself. Valves and seats made of a special mixture can be furnished for use with superheated steam. All parts made interchangeable. Our diaphragms are made of special flat stock and shape themselves. In an emergency any good sheet packing can be used temporarily. A special valve for vacuum heating systems is made with very large diaphragm and double-ended single lever, to reduce to atmosphere or below.

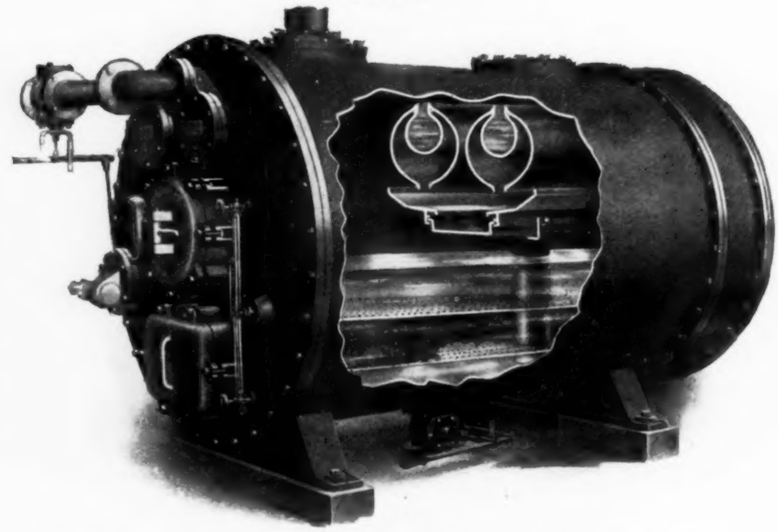
Write for Catalog.

THE NATIONAL PIPE BENDING CO.

Boston Office 54 High Street	Main Office and Works NEW HAVEN, CONN.	New York Office 149 Broadway

THE NATIONAL COIL OR CLOSED FEED-WATER HEATER. THE NATIONAL DIRECT CONTACT FEED-WATER HEATER AND PURIFIER. NATIONAL STORAGE HEATERS, NATIONAL STEAM AND OIL SEPARATORS, COILS AND BENDS OF IRON, BRASS AND COPPER PIPE.

THE NATIONAL DIRECT CONTACT FEED-WATER HEATER AND PURIFIER

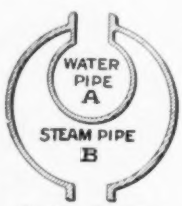


METHOD OF TRANSMITTING HEAT FROM EXHAUST STEAM TO THE WATER

From a regulating valve, the water enters a manifold cast on the front head of the heater which serves as a distributing chamber to the contact pipes, which consist of a double cast-iron pipe cast together one within the other, and closed at opposite ends.

The Water Pipe (A) has a port extending its full length upwards to the outside surface of the steam pipe with vertical walls isolating one from the other.

The Steam Pipe (B) has a port its full length at the bottom, through which all the steam must pass to enter the Heater.



Section of Contact Pipe

The water entering the water pipe flows upward through the port and passes in a thin film over the entire outer surface closely all the way around, until it reaches a rib projecting from each side of the port opening at the bottom of the steam pipe, where it is broken up into two sheets of fine spray.

The steam after passing through the Oil Separator enters the steam pipe, and the only outlet for the steam is the port at the bottom.

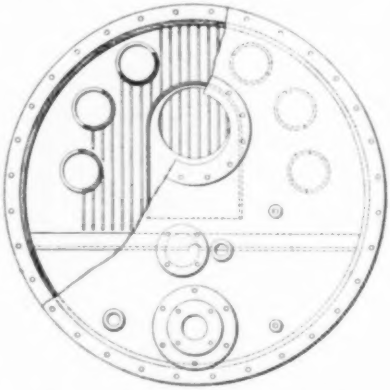
The Cold Water Pipe, being inside of the Steam Pipe, is surrounded by steam and the coldest water and hottest steam are first brought together through contact with the thin walls of the Water Pipe, then the pre-heated water is further heated as the thin film of water passes over the outer surface of the steam pipe, and finally all of the water and all of the steam are brought into direct and actual contact.

THE NATIONAL PIPE BENDING CO.

THE OIL SEPARATOR

The Oil Separator is part of the Heater and forms the back head and is of the same diameter as the shell. It is of the gravity type, having a multi-ported baffle plate, each port having an individual baffle.

These individual baffles are obtained by having an opening in the back of pipes which extend from the ports in baffle plate to the outer wall of the Separator. They absolutely prevent oil from being carried into the heater. The large cubical capacity of the Separator not only insures the effective separation of oil from the exhaust steam, but it also overcomes the pulsations of exhaust and gives an even flow of steam to the heater.



Oil Separator (Part of the Heater itself)

FILTRATION

Upward filtration is used. A large sediment chamber in the bottom of heater relieves filter bed of unnecessary work. A quick-opening blow-off valve on outlet from sediment chamber affords opportunity for draining heater and also causes a reverse current through filter bed, giving it longer life.

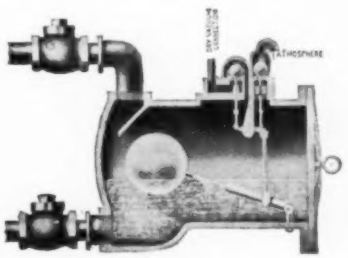
Patent applied for

THE NATIONAL HORIZONTAL OIL SEPARATOR

This Separator absolutely removes the grease or cylinder oil from exhaust steam so that the steam, when condensed, is perfectly suitable for boiler feed, laundry, or dye house service, ice making, or any other similar purpose.

Note the multi-ported baffle plate, each port having an individual baffle, a distinctive feature found only in the National Separators.

THE
STRONG, CARLISLE & HAMMOND CO.



Strong Vacuum Trap

The Strong Vacuum Trap automatically removes water from the vacuum lines of condensing engines, from the receivers of compound engines, from vacuum oil separators, etc., thus preventing accidents which might otherwise occur from the back suction of water into engine cylinders.

The Strong Vacuum Trap is also designed for returning condensation from coils, radiators, etc. of low pressure heating systems, direct to the boiler.

CONSTRUCTION.—The Trap consists of a cylindrical shaped body made from a high grade of cast iron, to which is bolted the head. This joint is machined and absolutely tight. To the top of the trap is attached the frame for the valves with a dry vacuum and atmosphere ports as shown by cut. Into this frame are screwed the seats for the vacuum and atmospheric valves. The valves consist of ground brass balls, operated by levers having heavy phosphor bronze bearings. The mechanism is operated by a Hercules patented copper float connected by heavy phosphor bronze and brass rods. No steel or iron is used in the working parts. The traps have no trunnions to adjust, no stuffing boxes to pack, no tilting devices to balance, and REQUIRE NO STEAM TO OPERATE THEM when discharging the water to the atmosphere and only a sufficient amount of steam to balance the back pressure when discharging to an elevation.

There is not a delicate part in their construction. The valves are in the top of the trap and may be inspected by removing the small caps encasing them. It is impossible for dirt to get at the working parts, as they are above the water line and almost the length of the trap away from the inlet. Every trap is inspected and rechecked before leaving our factory, and is ready to go into service.

TABLE OF SIZES AND CAPACITIES

Size No.	Outlet and Inlet	Distance Floor to Inlet	Total Length	Total Height	Diameter Body	Diameter Flange	Capacity Gallons Hour—Over	Shipping Weight	List Price
	Inches	Inches (Center of Inlet)	Inches	Inches	Inches	Inches			
8	1½	16	24	23	11	14	400	235	$120.00
9	2	21½	28	29	18	20½	700	410	200.00
10	2½	21½	28	29	18	20½	1000	410	200.00
11	3	21½	28	29	18	20½	1600	410	200.00

Swing check valves are furnished for inlet and outlet. Ball and lift checks should not be used

Discount on application

THE OHIO BRASS CO.

MANSFIELD, OHIO

OHIO STEAM SPECIALTIES

Ohio Regulating Valve

OHIO PRESSURE REGULATING VALVE

FOR STEAM OR AIR

Patented

Reduces and regulates accurately and continuously.

Self-contained, no tight fits, will not stick.

Simple and rugged in construction.

Made in all bronze in ½ to 2 inches.

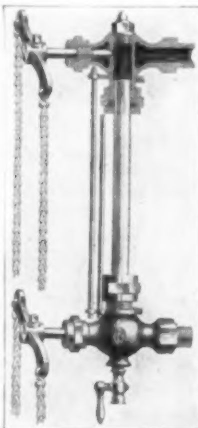
Made in iron body with bronze working parts in 2½ to 4 inches.

OHIO WATER GAUGE

Comes packed with high grade packing, ready to use.

Quick opening—opens or closes with a quarter turn of levers.

Made of high grade steam bronze in ½ and ¾ inch.



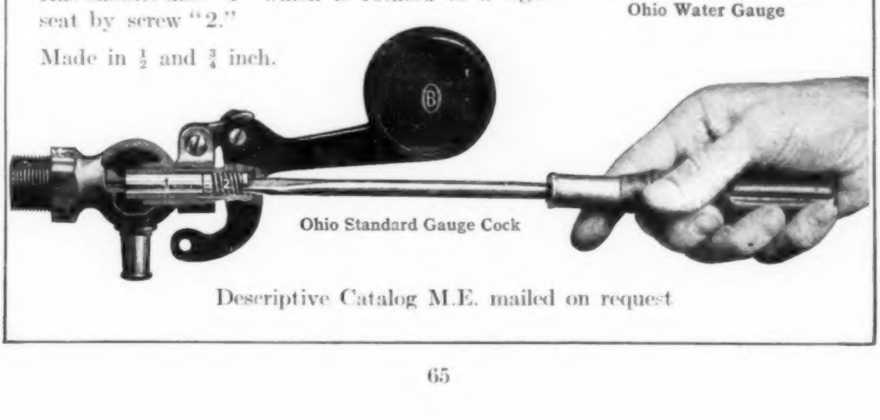
Ohio Water Gauge

OHIO STANDARD GAUGE COCK

A simple twist of the wrist stops a leak.

Has babbitt disc "1" which is rotated to a tight seat by screw "2."

Made in ½ and ¾ inch.



Ohio Standard Gauge Cock

Descriptive Catalog M.E. mailed on request

PITTSBURGH VALVE, FOUNDRY & CONSTRUCTION CO.

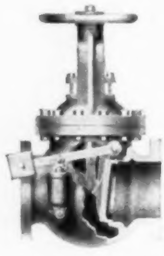
PITTSBURGH, PA.

ENGINEERS, MANUFACTURERS AND ERECTORS

Designers and Builders of Valves, Fittings and Appliances of Every Description for Steam, Gas, Water, Air and Hydraulic Piping.

Designs and Estimates for special valves and equipment furnished upon receipt of specifications.

Atwood Horizontal Separator



Outside Dashpot Non Return Valve

48″ Double Spindle Gate Valve

120″ Butterfly Valve

Hand Operated Gate Valves.
Electrically Operated Gate Valves.
Cylinder Operated Gate Valves.
Quick Opening Gate Valves.
Globe, Angle and Cross Valves.
Check Valves.
Butterfly Valves.
Critchlow Operating Valves.
Tanner Operating Valves.
Aiken Operating Valves.
Relief Valves.
Back Pressure Valves.
Non Return Valves.
Throttle Valves.
Transfer Valves.
Register Valves.
Float Valves.
Foot Valves with Strainers.
Blow Off Valves.
Plug Valves.
Hydraulic Cocks.
Tuyere Cocks.
Hydraulic Spring Cushions.
Gas Line Materials.
Pressure Regulating Stations.
Cast Iron Pipe.
Pipe Fittings and Flanges.
Pipe Bends.
Expansion Joints.
Exhaust Heads.
Steam Separators.
Drip Pockets.
Strainers.

PITTSBURGH VALVE, FOUNDRY & CONSTRUCTION CO.

PITTSBURGH, PA.

GATE VALVES

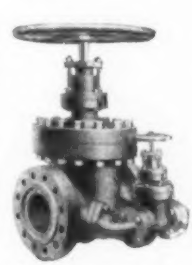
SPECIFICATIONS FOR MATERIAL	Grey Iron—22,000 lb. per sq. in. tensile strength. Semi Steel—33,000 lb. per sq. in. tensile strength.
PARALLEL SEAT 50 lb. WORKING PRESSURE 100 lb. TEST PRESSURE	Sizes 14″ to 72″ cast iron. Low pressure. For water, gas, air or exhaust steam. Extremely close face to face, invaluable in complicated piping connections.
PARALLEL SEAT 125 lb. WORKING PRESSURE 300 lb. TEST PRESSURE	Sizes 2″ to 48″ cast iron. Standard pressure. For water, air, steam or gas. Fully bronze mounted. Especially adapted to water distribution.
PARALLEL SEAT 200 lb. WORKING PRESSURE 400 lb. TEST PRESSURE	Sizes 1½″ to 16″ cast iron. Largely used for natural gas under the lower pressures. Furnished either all iron or iron body bronze mounted.
PARALLEL SEAT 400 lb. WORKING PRESSURE 800 lb. TEST PRESSURE	Sizes 3″ to 20″ semi steel. In extensive use for the transmission of natural gas. Furnished either with or without bronze mountings.
PARALLEL SEAT 500 lb. WORKING PRESSURE 1500 lb. TEST PRESSURE	Sizes 2″ to 12″. For water or oil at pressure noted. Semi steel with solid bronze mountings.
PARALLEL SEAT 1000 lb. WORKING PRESSURE 1500 lb. TEST PRESSURE	Sizes 2″ to 12″ semi steel. High pressure gas valve used chiefly at the gas wells and on feeders in the gas fields.
PARALLEL SEAT 1500 lb. WORKING PRESSURE 2000 lb. TEST PRESSURE	Sizes 2″ to 10″ semi steel. For hydraulic service and extreme natural gas rock pressures.
TAPER SEAT 175 lb. WORKING PRESSURE 500 lb. TEST PRESSURE	Sizes 2″ to 16″ semi steel. A valve for medium steam pressures from 125 lb. to 175 lb. where a less expensive valve than the 250 lb. type is desired.
TAPER SEAT 250 lb. WORKING PRESSURE 800 lb. TEST PRESSURE	Sizes 1½″ to 28″ semi steel Made of semi steel with solid bronze mountings for ordinary steam pressures or of cast steel with monel mountings for superheat.
TAPER SEAT 1000 lb. WORKING PRESSURE 2000 lb. TEST PRESSURE	Sizes 2″ to 10″. The strongest valve possible to make in its weight, all surfaces being cylindrical or spherical segments.
GATE VALVES FOR ANY PRESSURE	Designs and quotations furnished for valves for special conditions or higher pressures. Materials used are those best adapted to service.

(See also next page)

50 lb. Parallel Seat Gate Valve. Close Pattern

8″ 500 lb. Gate Valve

4″ 1000 lb. Gas Line Gate Valve

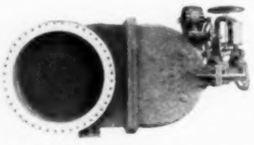


6″ 1000 lb. Hydraulic Gate Valve

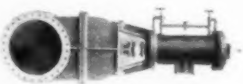
(Continued from preceding pages)

PITTSBURGH VALVE, FOUNDRY & CONSTRUCTION CO.

PITTSBURGH, PA.



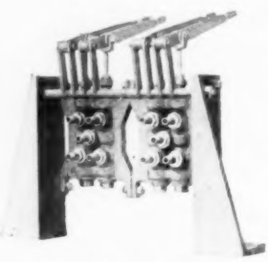
48" Motor Operated Gate Valve



30" Gate Valve Operated by Air Cylinder

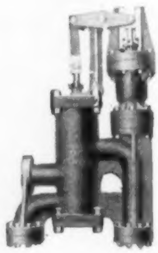
Any of the foregoing gate valves may be equipped with operating cylinders for any service or pressure, or motors for either direct or alternating current.

The following types of operating valves are extensively used for the control of motion of hydraulic cylinders, either single or double acting.



Group of Two Critchlow Nests

The **CRITCHLOW VALVE** is the simplest form of hydraulic three or four way piston valve and has no superior for working pressures up to 500 pounds. It is durable and easy to repack. The CRITCHLOW NEST furnishes a means of grouping these valves which yields a great saving in pipe, fittings, manifolds and space, where a number of cylinders are to be operated from one pulpit.



Tanner Valve with Actuating Cylinder

The **TANNER VALVE** is more satisfactory than the Critchlow on high pressures. It is of the cup-packed piston type, so designed that the fluid forces the packing away from the ports instead of into them, prolonging the life of the packing and making operation easy. The arrangement of supply and waste ports facilitates attaching to manifolds. Larger sizes can be furnished with actuating cylinder permitting remote control by means of a pilot valve.

The **AIKEN VALVE** has given complete satisfaction to a large number of users for many years. The designs and patterns for this valve have been purchased from the inventor, Henry Aiken, M.E., and valves can be made to meet any requirements.

Special facilities for casting and machining large pipe and fittings as well as all classes of work such as furnace castings, general castings, etc.

60" x 42" x 42" x 42" Special Cross with 30" Side Outlet

PITTSBURGH VALVE, FOUNDRY & CONSTRUCTION CO.

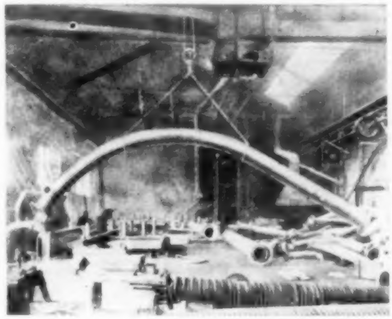
PITTSBURGH, PA.

PIPING SYSTEMS

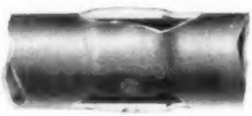
For all Pressures and Purposes, Designed, Manufactured and Installed

Pipe Bending Pipe Cutting Pipe Fitting

Estimates furnished on receipt of specifications



20″ Expansion Bend—Radius 16 Ft. This bend contains 38 ft. of pipe and was made of two lengths joined in the arc by the Atwood Line Weld



The Atwood Line Weld
Patented

THE ATWOOD LINE WELD

This method of joining the abutting ends of wrought pipe allows the fabrication of pipes into lengths as long as can be handled for shipment with consequent reduction by about 50 per cent of the number of flanged joints in the line.

The Interlock Welded Neck
Patented

INTERLOCK WELDED NECKS

This method of connecting branch lines of wrought pipe to mains of the same material was developed in response to the demand of steam users for a structure containing the minimum number of joints. Every branch so connected eliminates a cast fitting with its attendant joints, gaskets and bolts and liability to trouble therefrom.

The Atwood Joint

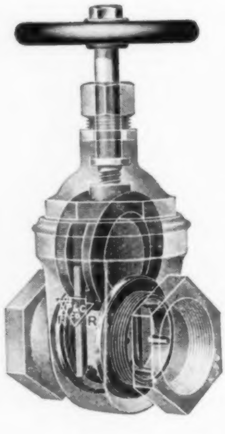
FLANGED JOINTS

Atwood, Screwed, Shrunk, Expanded and Welded.

THE PRATT AND CADY COMPANY

HARTFORD, CONN.

VALVES FOR ALL PURPOSES



GATE VALVES

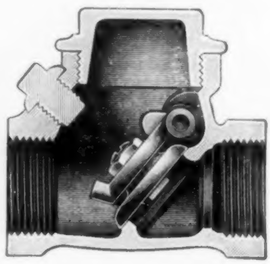
With renewable seat rings, held in place by a retaining ring that is easily removed.

Screw Hub, Stationary Spindle, Retaining Ring Construction.

The seat rings are independent rings of bronze, or any special metal or material best adapted for the service in which the valve is to be used. The gate is a double faced, wedge shaped casting, with side grooves by means of which it slides on guides in the valve body.

Great pains are taken in the machining of all parts of these gate valves. Gauges are used on each part to insure their accuracy and interchangeability.

The guides in our bodies are of equal thickness, and the wedge can be taken out of the valve and replaced with the opposite faces in contact, and will give an accurate fit. The importance of this in making repairs is obvious. These valves being double seated, can be used with the pressure applied at either end.



REGRINDING SWING CHECK VALVES

Brass and Iron

All styles for all pressures, sizes up to 48 inches.

The *Design* combines pressure resistance with easy flow lines. Material (of brass valves) is 86% pure copper. We use no scrap in their production. *Workmanship*—Each valve is individually tested to the pressure stated in catalog. All seats are carefully ground. Assembling is done by our most careful hands. The *Interior Construction* permits the replacement of any working part without removing valve from line. *For Regrinding* no tool is necessary but a wrench and brace and bit.

ASBESTOS-PACKED COCKS

The dovetailed U-shaped grooves in the body are packed with prepared asbestos. An asbestos ring is used on the shoulder of the plug for top packing.

The plug is of standard taper carefully finished and barffed to render it rustless. It has no metallic bearing, coming in contact only with asbestos, the elasticity of which compensates for the differential expansion and contraction of the plug and body. The gland admits of adjustment by means of its bolts.

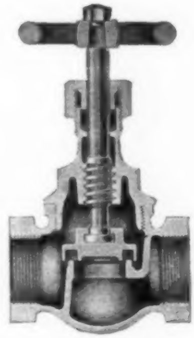
These cocks give exceedingly satisfactory results as a boiler blow-off and a water column blow-off, between check and boiler, between water column and boiler, and they do work where ground plug cocks are unsatisfactory and where Globe, Angle or Gate Valves fail.

THE PRATT AND CADY COMPANY

HARTFORD, CONN.

VALVES FOR ALL PURPOSES

ASBESTOS DISC VALVES



The Stuffing Box Gland is long, heavy and well fitted.

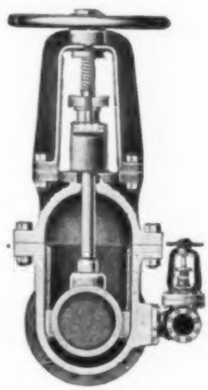
The Spindle Collar, and its point of contact with the bonnet, have specially smooth surfaces and make a steam-tight joint when valve is fully open.

The Disc Holder is guided by four splines in the body, assuring perfect alignment at all times. The Disc Holder is of the horseshoe type, and can be removed and replaced, the only tool necessary therefor being a wrench to unscrew the bonnet.

The Seat is spherical, thus preventing the settling thereon of any substance that might hold the disc from going squarely to its place. The metal used in the construction of these valves is approximately 86% pure copper. We use no scrap whatever in the construction.

The Valve complete is finished with the utmost care. When so ordered, these valves can be made with solid brass disc, or with brass disc holder filled with special metal, at additional price.

CAST STEEL GATE VALVES FOR SUPER-HEATED STEAM



All Valves $2\frac{1}{2}$" and larger are equipped with Cast Steel Bodies, Bonnets and Wedges.

The Seats and Faces of the Wedges are made of Pure Nickel, securely fastened in place so that they will be unable to work loose.

Stems are Nickel Steel.

All Bolt Holes are Spot Faced.

Bonnet Joint is packed with "Palmetto" Superheat Packing.

The End Flanges have $\frac{1}{16}$" Raised Faces, extending full width inside of Bolt Holes, with smooth finish.

All Bolts have Hexagon Heads and Nuts, with the under side of same semi-finished.

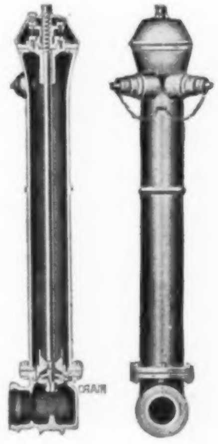
The Discs are of the Wedge Pattern.

Stuffing Box is made with Hinge Bolts, very deep for square "Palmetto" Packing.

Yoke is bolted to the Bonnet.

All tested to a hydrostatic pressure of 800 lbs..

COMPRESSION TYPE HYDRANTS



Without Intricacy of Construction.

Complete catalog of all Pratt and Cady products on request.

WALWORTH MANUFACTURING CO.

Established 1842

132 FEDERAL ST., BOSTON, MASS.

Works, South Boston. New York Office, Park Row Building.

Manufacturers of

HEAVY PRESSURE POWER PLANT PIPING MATERIALS

The WALWORTH up-to-date Catalog to be issued in 1912 will give full details, with illustrations, dimension Tables, etc., and will be furnished on request to interested parties. Write Department E.

The following will give you a general idea of our complete line—furnished both STANDARD and EXTRA HEAVY:—

WALMANCO FLANGED-OVER THREADLESS PIPE JOINTS, swivel ends for 250 pounds working pressure.
WALWORTH LONG SWEEP FLANGED AND SCREWED FITTINGS.
WALWORTH WROUGHT IRON OR STEEL PIPE BENDS, with threaded or Walmanco Joints.
WALWORTH ELBOWS, TEES, CROSSES, FLANGES, etc. (Brass and Iron), for all pressures.
"WALCO" MALLEABLE IRON BRASS SEAT UNIONS, ground joint.
FLANGES, Standard and Extra Heavy.
WROUGHT IRON PIPE WITH WELDED FLANGES.
STEEL PIPE DRUMS, with welded pipe nozzles riveted on, using Walmanco or welded flanges.
CAST IRON FLANGED PIPES.
CAST IRON BRACKETS, ROLLER CHAIRS AND FLOOR STANDS.
QUICK CLOSING SAFETY DEVICE FOR WATER GAUGE COLUMNS.
INJECTORS AND POP SAFETY VALVES.
ENGINE AND BOILER TRIMMINGS, WATER GAUGES, etc.

WALWORTH HIGH-GRADE GATE VALVES,

With Renewable Bronze Seats. Outside Screw and Yoke or Stationary Spindle. Spindles either Bronze or Steel. Can be repacked under pressure. Sizes up to 42 inches diameter.
STANDARD IRON BODY BRASS MOUNTED GATE VALVES for 125 pounds working pressure.
MEDIUM IRON BODY BRASS MOUNTED GATE VALVES for 175 pounds working pressure.
EXTRA HEAVY IRON BODY BRASS MOUNTED GATE VALVES for 250 pounds working pressure.
HYDRAULIC BRASS MOUNTED GATE VALVES, for 800 pounds working pressure.
BRASS GATE VALVES, standard and Extra Heavy.
"WALCO" BRASS GATE VALVES, for 125 pounds working pressure,
STANDARD AND EXTRA HEAVY IRON BODY GLOBE AND ANGLE VALVES,
Never-Stick Boiler Blow-off Cocks,
AUTOMATIC STOP VALVES, extra heavy.

For Heavy Pressure Piping we furnish:
WALWORTH SEMI-STEEL CASTINGS
For Drums, Valves and Fittings
(Average Tensile Strength, 33,500 Pounds)

We also manufacture a complete line of Pipe Fitters' Tools, Stocks and Dies, Pipe Cutters, Vises, etc., including the—

STILLSON GENUINE STILLSON WRENCH STILLSON
which bears the Diamond Trade Mark.

S. F. BOWSER & COMPANY, Inc.

Established 1885

FORT WAYNE, IND.

New York Boston Philadelphia Chicago St. Louis
San Francisco Minneapolis Dallas Atlanta Toronto

OIL SYSTEM ENGINEERS AND MANUFACTURERS

Oil System Engineers and Manufacturers of:

Oil Distributing Systems.

Self-Measuring Hand and Power Driven Pumps.

Underground Storage Systems.

Large Tankage.

Oil Storage Systems.

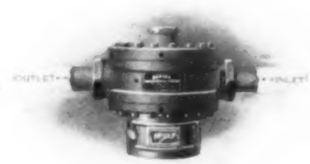
Automobile Filling Stations.

Dry Cleaning Systems.

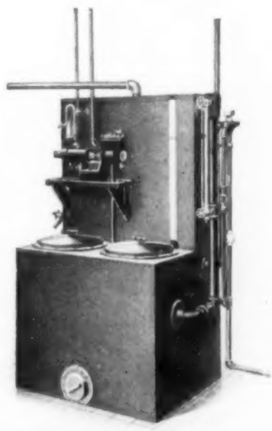
Self-Registering Pipe Line Measures.

Oil and Gasolene Storage Outfits for Public and Private garages.

Oil Filtration and Lubricating Systems.



Registering Measure



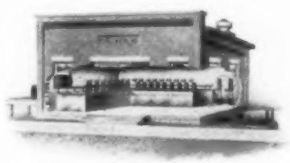
Filtration System

The Bowser line covers every requirement of the factory and railroad for oil storage equipment.

Our corps of mechanical and drafting engineers is at the command of those interested in this line.

Bulletins giving complete detailed description of any line will be furnished upon application and without obligation. We have a fund of information on oil storage and allied lines that will assist in making up specification for this work. Let us submit it.

Our catalogue No. 12B illustrates and describes the line in a limited way and shows a large number of installations in widely diversified fields. Write for it.



Oil House

PITTSBURGH GAGE & SUPPLY CO.

PITTSBURGH, PA.

NEW YORK CITY: 136 Liberty St. BOSTON, MASS.: 54 High St. CHICAGO, ILL.: 174 N. Market St.

LUBRICATING APPLIANCES

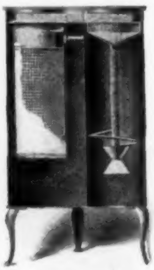
WHITE STAR OIL FILTERS AND OILING SYSTEMS

White Star Oil Filters are made in the following types:

Round: For small plants where a continuous oiling system is not contemplated, and delivery of oil is made to Filter by hand.

Duplex: For use in connection with automatic continuous oiling systems.

Multiplex: For oiling systems in very large plants. They are made for handling as much as 6000 gallons of oil per day.

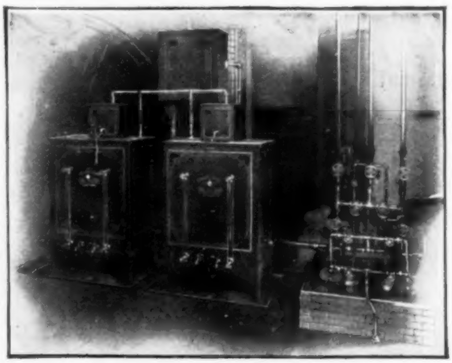


ROUND TYPE

Number of Filter	Filtering Capacity Gallons per 24 Hours	Holding Capacity, Gallons			List Price for Hand Operation	Shipping Weight lbs.
		Pure Oil	Dirty Oil	Water		
2	20	7½	5½	5	$35.00	115
4	35	9½	7½	6½	50.00	127
5	50	12	10	9	60.00	142
7	65	15	13	12	75.00	165
10	80	19	17	16	85.00	190
12	100	25	18	20	100.00	225

DUPLEX AND MULTIPLEX TYPES

Number of Filter	Filtering Capacity, Gallons per 24 Hrs.	Holding Capacity Gallons			List Price	Shipping Weight, lbs.
		Pure Oil	Dirty Oil	Water		
8	100	13	10	8	$95.00	190
17	150	38	11	8	125.00	285
20	200	64	17	14½	150.00	400
23	350	50	30	25	300.00	620
25	500	103	40	45	400.00	850
27	700	100	40	25	500.00	1000
50	1000	115	105	67	600.00	1500
100	2000	235	125	90	800.00	2000
150	3000	353	182	119	1000.00	2500
200	4000	476	257	177	1200.00	3000
250	5000	589	320	236	1500.00	3600
300	6000	710	365	236	1800.00	4200



A Typical Duplex Installation.

On request we will furnish bulletins showing our complete line of special Rotary, Double Acting, Simple and Duplex Pumps, Reservoirs, Separating and Drain Tanks, Sight Feeds, Compression Fittings, Piping Materials and accessories, special oiling devices and Force Feed Cylinder Lubricators.

In addition to manufacturing lubricating appliances, we make:

Gaco Safety Water Gages; a self-closing gage, the valves of which close instantly in case gage glass breaks.

Gaco Take-Down Gage Cocks—can be taken down under full head of boiler pressure.

Pittsburgh Safety Water Columns—Equipped with combined high and low water alarm attachment.

Pittsburgh Steam and Oil Separators—For removal of water and oil from live steam.

Pittsburgh Recording Gages—For recording pressure of steam, oil, gas, air; also vacuum.

Pittsburgh Vacuum Exhaust Heads—For removal of water, oil, etc., from exhaust steam.

Gaco Dust Collecting Systems.

Pipe Bends and High Pressure Piping Work a specialty.

THE STERLING MACHINE COMPANY

NORWICH, CONNECTICUT

ACME ENGINES, STATIONARY AND MARINE; DIRECT CONNECTED GENERATOR UNITS; STERLING LUBRICATORS FOR AUTOMATIC FORCE-FEED LUBRICATION

Model A

Model B

STERLING FORCE FEED LUBRICATORS

are high grade oil pumps for providing positive lubrication with the minimum amount of oil. They are entirely automatic in action and save time as well as oil.

Model A is designed for use on steam engines and pumps and is made in the following sizes:

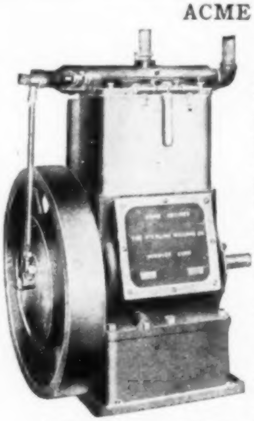
Number of Feeds	One						Two					Three			
Tank Capacity...	1 Pt.	1 Qt.	3 Pt.	½ Gal.	1 Gal.	1½ Gal.	1 Qt.	3 Pt.	½ Gal.	1 Gal.	1½ Gal.	3 Pt.	½ Gal.	1 Gal.	1½ Gal.

Model B is intended for use on large units and is especially adapted for lubricating the valves and cylinders of large gas engines, air compressors and similar units.

This model can be built in any capacity with any number of feeds. Standard sizes as follows:

Number of Feeds	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Tank Capacity...	4 Pt.	5 Pt.	6 Pt.	1 Gal.	1¼ Gal.	1¼ Gal.	1¾ Gal.	1¾ Gal.	2 Gal.	2 Gal.	2¼ Gal.	2¼ Gal.	2¾ Gal.	2¾ Gal.	3 Gal.	3 Gal.

ACME STATIONARY STEAM ENGINE



Acme Stationary Engine

This Engine is an upright, double-cylinder single-acting engine, with cranks 180° to each other; pistons being 1½ times the stroke in length, form their own guides. Cranks are of drop forged steel, large size in diameter and length. Main bearings are 2½ times diameter of shaft, bushed with bronze, and can be renewed when worn, at small cost. Valve is of the balanced rocking type, of extra long and large wearing surfaces, and is placed on top of cylinders, the valve-case forming the cylinder heads. Lubrication is accomplished by carrying in the crank case a mixture of oil and water, into which the cranks dip at every revolution, and are not only flooded themselves, but throw the oil to every part inside the case.

These Engines are especially adapted for Mechanical Stokers, Small Independent Electric Light Equipments, Centrifugal Pumps, and for use with Exhaust or Ventilating Fans, Blowers, etc. Catalogues on request.

ACME ENGINE SIZES FROM ONE HALF TO THIRTY-FIVE H.P.

Engine Model	1	2	3	4	5	6	7	8	9	10
Bore (inches)	2¼	3	3 5/16	3 5/8	4	4 9/16	5	5	6	7
Stroke (inches)	3½	3½	3½	5	5	5	5	7	7	7

Any of the above sizes may be operated at a speed up to 600 R.P.M.

A. ALLAN & SON

494 GREENWICH STREET

NEW YORK

SOLE MANUFACTURERS OF ALLAN BRONZE, ALLAN RED METAL, ALLAN METAL VALVE DISCS, ALLAN BEARING BRONZES

BEARING BRONZE

The Essentail Qualities of a High Grade Bearing Bronze are:

That it will sustain the load without rupture.

That it will make the friction between the bearing and shaft as low as possible.

That it will give the longest possible service, with the smallest possible loss of metal by wear.

That it will require only a minimum amount of lubrication.

That it will not have a tendency to heat rapidly, causing the bearing to hug and tear the shaft.

A bearing alloy with these qualities is the highest standard of efficiency and a guarantee of low maintenance cost.

It is universally conceded that lead-copper-tin alloys possess the essential qualities of a high grade bearing bronze, but owing to the difference in specific gravity and fusing points of these metals, it is impossible to produce by ordinary foundry practice, lead-copper-tin alloys high in lead, without lead sweat or segration.

Our alloys are not made by rule-of-thumb methods, but by the Allan process, the process whereby lead-copper-tin can be mixed into a homogeneous bronze. They are made from the best brands of Virgin metals.

It is impossible to produce a bronze of standard proportions which will be universally satisfactory for all work and conditions. To meet these conditions Allan Bronzes are made in several grades, according to service for which they are specified.

We recommend Allan No. 4 Bronze for crank-pin brasses, piston pin bearings on gas engines, driving boxes and rod brasses on heavy and high-speed locomotives. Allan No. 2 Bronze for thrust bearings on vertical rolls, pinion bearings on plate mills, where high temperature and excessive pressures are to be met.

Write our Engineering Department your service conditions. We give the most liberal guarantee of quality and efficiency.

A. ALLAN & SON

494 GREENWICH STREET

NEW YORK

SOLE MANUFACTURERS OF ALLAN BRONZE, ALLAN RED METAL, ALLAN METAL VALVE DISCS, ALLAN BEARING BRONZES

ALLAN RED METAL

For Bearings, Pistons and Packings

The introduction in locomotive, marine and stationary engine construction of the use of superheaters, and the results of greater efficiency thereby derived, is a noteworthy advancement in modern engineering practice. But with this forward movement arises troublesome details which have to be met and overcome.

One, of no little moment, is the need of a babbitt or antifriction metal to cope with the excessive heat of highly superheated steam. Allan Red Metal will give satisfactory service with steam at 175 pounds pressure and 200° superheat. It was never intended to displace white babbitt metal—but to overcome its shortcomings—to do the work white babbitt metal will fail to do.

Allan Metal faced pistons are recognized by mechanical engineers as the most advanced design in piston construction.

As shaft packing on steam turbines it has proven its efficiency over carbon.

It is a bearing alloy that cannot be melted out of a bearing, even under the most severe service condition, nor will it hug, stick to, scar or cut the pin or shaft.

Allan Metal Globe Valve Discs supersedes the vulcanized disc, due to their lasting qualities.

Allan Red Metal is as great an advancement in the metallurgy of antifriction metal as superheated is to saturated steam. They are both forward movements to greater efficiency in modern engineering practice.

Our Booklet, "The Heart of the Engine—The Seat of Power," is a treatise on piston design and will be mailed free upon request.

MAGNOLIA METAL CO.

NEW YORK
113-115 Bank Street

CHICAGO
Fisher Building

MONTREAL
225 St. Ambroise St.

MAGNOLIA METAL

FAC-SIMILE BAR OF MAGNOLIA METAL

COEFFICIENT OF FRICTION Tests by great governments and eminent mechanical experts all show that Magnolia has the smallest coefficient of friction of any known bearing metal. The United States Government test—when *water* was used as the lubricant—300 lbs. pressure per square inch, 491 R. P. M., showed a frictional coefficient as low as 0.0008. The test by the French Government —710 lbs. pressure per square inch, 6.56 ft. per second—lubricant "black oil," showed coefficient 0.0012.

WEARING QUALITIES Magnolia ran over twenty-three years on log mandrel bearings and was in good condition when plant was permanently shut down. It is the rule rather than the exception for Magnolia lined bearings to run for five and ten years and longer.

HEAVY PRESSURES Thousands have testified that Magnolia is the only metal that will stand the heavy pressure on their bearings: proving superior to and out-wearing bronze and brass in Rolling-mill work, etc. Professor John Goodman, the well known English authority, says of Magnolia—"The higher the pressure that is applied to a Magnolia bearing, the better does the wearing surface become." He tested it up to two tons per square inch.

HIGH SPEED Magnolia is used largely in thousands of wood-working and other plants where both the speed and duty are very severe and is extolled for its lasting and other qualities. It commonly runs in such places from four to fifteen years.

LUBRICATING QUALITIES Magnolia is largely a self lubricating metal. In the *water* test by the U. S. Government Magnolia was run for 5 hours up to 600 lbs. inch^2 pressure—the limit of machine—490 R. P. M., and proved to be 200% superior antifrictionally to a conventional Babbitt of the same formula as Magnolia but not subjected to the same special foundry treatment and 1100% superior to white brass. Magnolia has run six years on shafting bearing without a drop of lubrication and Engineers very often speak of large saving in oil on Magnolia bearings.

GRIT We have great numbers of letters laying particular stress upon the wonderful wearing qualities of Magnolia bearings that are subjected to grit and dust in Cement Mixers, etc. etc.

DETAILS We will gladly send our advertising literature giving full particulars to any one interested.

TAYLOR INSTRUMENT COMPANIES

ROCHESTER, N. Y.

"Where *Tycos* Thermometers Come From"

NEW YORK	BOSTON	CHICAGO
Bank of Metropolis Bldg.	44 High Street	Heyworth Building
31 Union Square		29 E. Madison St.

MANUFACTURERS OF A COMPLETE LINE OF INSTRUMENTS FOR THE INDICATING, RECORDING AND REGULATING OF TEMPERATURE AND PRESSURE.

"*Tycos*" Thermometers for every purpose and application, including the famous H&M "*Tycos*" Type; "*Tycos*" Recording Thermometers in both Self-Contained and Capillary form; "*Tycos*" Index Thermometers, etc., Indicating and Recording any range of Temperature from minus 328°F to 1000°F.

H & M "*Tycos*" Automatic Temperature and Pressure Regulators for processes requiring uniformity of Temperature or pressure conditions.

"*Tycos*" Time Valves, in conjunction with H&M "*Tycos*" Regulators, make it possible to continue a process at a given temperature for a desired period of time, at the expiration of which the steam line is closed off and the exhaust opened, terminating the process.

"*Tycos*" Rotary Switchboards are made for the control of any number of High Temperature Stations, up to and including twenty.

"*Tycos*" Pyrometers—

Base-Metal from 200°F to 1800°F.

Rare-Metal from 1000°F to 2500°F.

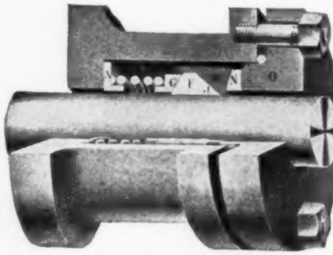
Foster "*Tycos*" Fixed Focus Pyrometer is the most dependable portable instrument.

FERY RADIATION PYROMETER has no top limit. It is extremely sensitive and in action is almost instantaneous.

C. LEE COOK MANUFACTURING CO.

LOUISVILLE, KY., U. S. A.

COOK'S METALLIC PACKING FOR STEAM, GAS AND AIR, ON POWER ENGINES OF EVERY DESCRIPTION; ESPECIALLY ADAPTED TO EXTRA HEAVY DUTY SERVICE ON REVERSING BLOOM MILL ENGINES, BLOWING ENGINES, ROLLING MILL ENGINES, GAS ENGINES, MARINE ENGINES, LOCOMOTIVES, AND ENGINES OPERATING UNDER VERY HIGH STEAM PRESSURE AND SUPERHEAT.

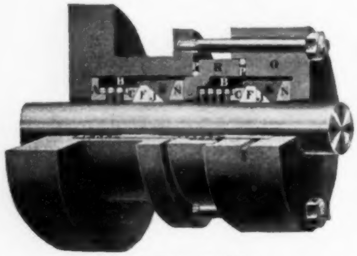


No. 1 Type Packing

SINGLE TYPE PISTON ROD PACKING

Is familiar to every leading engine builder in the United States. We have had satisfactory and agreeable business relations with them all.

It is simple, and economical as compared with other types of Metallic Packing, and has special merit not afforded by others. An examination of its construction will be proof sufficient that it is *steam tight*, will not cut, or score the rod, and operates with minimum friction.



No. 2 Type Packing

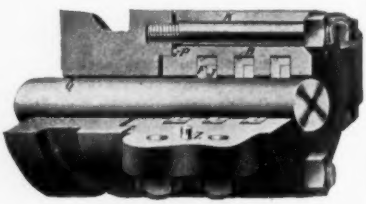
DOUBLE TYPE PISTON ROD PACKING

A trying difficulty before the successful operation of Metallic Packing, is the elimination of condensation. We accomplish this by placing two sets of Metallic Packing together, as seen in the cut. The upper, or main set, holds the pressure while the lower set arrests the water and conveys it to the threaded opening "T" of the lower Gland "O." A valve and a drain pipe is attached to this, and after the engine is hot, and condensation reduced to a minimum, the valve may be closed, thus putting into action two sets of packing, operating as one. Result: DOUBLE DURABILITY.

No. 3 Type Packing

CORLISS VALVE STEM PACKING

The cut delineates how simple is this packing's design. It is so near frictionless that there is no appreciable difference offered to the turning of the stem when the packing is on or off. Hence, when this packing is applied, the Valve Gear operates under a uniform condition, and averts the need of continual adjustment of dash-pots. For high vacuum service, we put two sets of this packing together, as illustrated in our Double Piston Rod Packing, and inject a steam seal under pressure through the opening which forms the drain in the former case. This hermetically seals the vacuum.



No. 6 Type Packing

SPLIT PISTON ROD PACKING

The cut delineates our outside type of packing cage, but we make it in any design that requirements or preference demands. Hence we can completely insert it in the stuffing box, using the fiber gland to hold it in place, or we can partly insert it with its outer end in the shape of a flange drilled to receive the studs, and thereby serve as the gland. We make packing rings for this type of packing in over six designs, all depending upon the preference of the engineer and the requirements of the service. A striking innovation in split packings is our copper gasket that forms a joint between the stuffing box and the packing case.

THE B. F. GOODRICH COMPANY

AKRON, OHIO

Offices in all principal cities

MANUFACTURERS OF MECHANICAL RUBBER GOODS, TIRES, ETC.

HOSE

WATER HOSE covers a wide range of usage, making it quite out of the question to advance any specific recommendations as to quality.

"WHITE ANCHOR" and "AKRON"—special grades for unusual conditions of service.

"TRITON," "CASCADE," "DELUGE,"—regular grades for all general purposes. Braided fabric water hose—in either smooth or corrugated cover.

STEAM HOSE must be heavily constructed to stand the pressure, and the inner lining must be so compounded as to resist the action of steam under varying temperatures.

"GOODRICH"—for high pressure. This is truly a long-life hose.

Special coverings for steam hose: Red Painted woven cotton cover, Woven Marlin Cover, Asbestos Wire-Wrapped cover.

PNEUMATIC HOSE wrapped duck—50′ length style:

"GOODRICH"—the highest quality for the hardest service.

"AKRON"—the standard hose, for all general purposes.

Wire wrapped pneumatic tool hose.

BRAIDED-FABRIC PNEUMATIC HOSE—smooth or corrugated.

AIR DRILL HOSE is heavily constructed throughout with a layer of canvas on the outside as a protection against cuts and abrasions.

"GOODRICH"—exceptionally high quality, unequalled for wear.

"QUARRY"—our standard grade and biggest seller.

BOILER WASHOUT HOSE is made in extra heavy weight to withstand the rough service it encounters. We advocate our heavy "Boiler Washout Hose" for turbine tube cleaner work. Made in two grades, "Goodrich" and "Akron."

SUCTION HOSE is made in a variety of grades to suit any purpose, either smooth or rough bore style.

DREDGING SLEEVES, OIL SUCTION HOSE, OIL WELL DRILLERS' HOSE, OIL CONDUCTING HOSE, GASOLINE HOSE, SAND BLAST HOSE, COKE HOSE, MARINE DECK HOSE, all especially adapted to the purposes for which they are made.

PACKING

RED SHEET PACKING—an excellent product, in two grades.

RED SHEET BRASS WIRE INSERTED in the same grades.

DIAPHRAGM AND CLOTH INSERTION: Packing highly recommended for their proper uses.

SUPER HEAT PACKING, a combination of rubber and asbestos, especially adapted for high pressures.

RED TUBULAR GASKET PACKING, SPIRAL SQUARE DUCK PACKING, ROUND AND SQUARE DUCK PACKING, SQUARE RUBBER BACK, ROUND PISTON PACKING, AND PURE GUM STRIPS all made to supply the demand for these various kinds.

RUBBER GASKETS

All grades and shapes. No matter what your requirements may be, we can supply them.

RUBBER PUMP VALVES

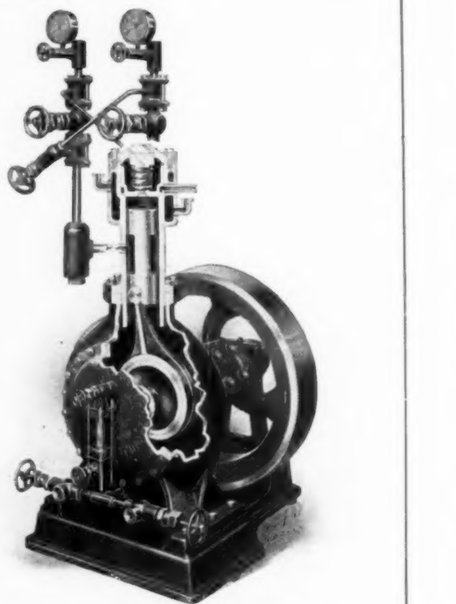
There is no class of our product which we take greater pride in stamping with the GOODRICH trade mark. Our list of grades is complete; we are always glad to give special attention to unusual conditions.

Made in grey or red rubber.

BRUNSWICK REFRIGERATING CO.

NEW BRUNSWICK, N. J., U. S. A.

REFRIGERATING AND ICE MAKING MACHINERY
For Private Residences and Estates.
MARINE REFRIGERATING AND ICE MAKING PLANTS.
COMPLETE PLANTS INSTALLED FOR COMMERCIAL REFRIGERATION OF ANY KIND



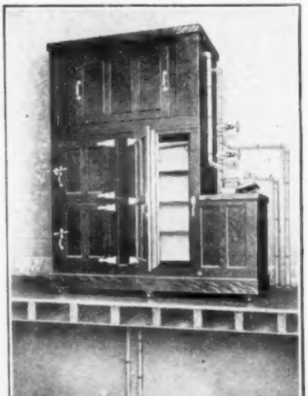
CONSTRUCTION

The "BRUNSWICK" is constructed throughout for maximum strength, efficiency, and durability. For private residence work the "BRUNSWICK" is acknowledged to be the most successful type on account of these features and its simplicity.

The COMPRESSOR is fool proof. Note the eccentric drive; the double set of piston rings; the safety relief valve inside of the discharge valve; the fact that the discharge valve is the full diameter of the cylinder. There is not a bolt or a nut inside of the crank case of the machine.

THE "BRUNSWICK" SYSTEM

"BRUNSWICK" experience has improved not only the compressor, but the whole system from the automatic expansion valve which is used on the smaller units through the expansion side of the plant, through the compressor, condenser, and back to the ammonia receiver. Nothing but the very best and strongest material is used. The fact that there are nearly 1,200 "BRUNSWICK" plants in operation today of 12 tons refrigerating capacity and less, 1,000 of which are under 6 tons capacity, is the best testimony that can be given regarding design, material and workmanship.



APPLICATION

RESIDENCES	**Confectioners**
STEAMSHIPS	**Dairies**
Clubs and Cafes	**Ice Cream Makers**
Office Buildings (ice water)	**Butchers**
Hotels	**Etc., Etc., Etc.**

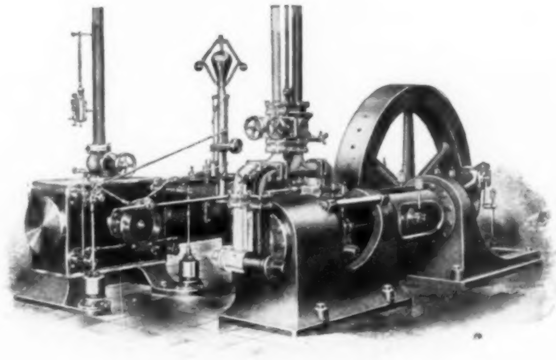
Send for list of residence installations. Send for list of steamships equipped with "BRUNSWICK" plants, or for general list of installations of all kinds.

The "BRUNSWICK" motto is not "Build the cheapest machine," but "Build the best." Our specialty is the small unit.

THE HUETTEMAN & CRAMER CO.

DETROIT, MICH.

REFRIGERATING AND ICE MAKING MACHINERY



The "Safety" Ammonia Compressor

FEATURES OF ADVANTAGE OF THE "SAFETY" REFRIGERATING MACHINE

This machine is designed to minimize the possibility of wreck or damage caused by a valve part or by liquid becoming imprisoned between cylinder and piston.

Due to the peculiar location of the compressor suction and discharge valves it is impossible for any valve part in case of breakage to enter the cylinder, and any shot of liquid that may come through the suction pipe will be forced out through the discharge valves, before the piston reaches the end of its stroke.

The machine is designed along the most improved and up-to-date lines, being of heavy duty construction throughout, and on account of being built horizontal it can be readily looked after and adjusted; also because of being made in sections, which in addition eliminates undue strains that exist in all large castings, it will permit of being installed in close quarters and in out of the way locations.

All working parts are provided with large wearing surfaces, every means of adjustment is provided, all these being readily accessible, and improved oiling devices are fitted to all wearing surfaces.

Because of its simplicity, accessibility and ready adjustment, it can be placed in charge of any average engineer with best results.

These machines are built for direct connection with engine or to be belt driven.

CAPACITIES IN TONS OF REFRIGERATION SIZES APPROXIMATE SPEEDS AND POWER REQUIRED

Tons Cap..	6½	8	9	11½	15	25	30	40	45	50	60	65	80	90	100	115	145	160
Bore........	5½	6¼	6	7	8	9	10	11	11½	12	13	13½	14	15	16	17	18	19
Stroke.....	12	12	14	14	16	18	20	22	22	24	26	26	30	30	32	32	36	36
R.P.M.....	90	90	85	85	80	80	75	75	75	70	70	70	65	65	60	60	60	60
Appr. H.P..	10	14	15	18	25	40	45	60	65	75	90	100	120	135	150	175	220	240

ALPHABETICAL INDEX TO CONDENSED CATALOGUES OF POWER PLANT EQUIPMENT

ALPHABETICAL INDEX TO DISPLAY ADVERTISEMENTS AND DIRECTORY CARDS